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The McDonald Observatory of the University of Texas

By S. A. MITCHELL

The opening of a great American observatory possessing the second largest telescope now in existence is an astronomical event of very first importance. Through the kindness of the Warner and Swasey Company I was privileged to participate in the ceremonies dedicating the McDonald Observatory.

I had before made many trips to Texas for the simple reason that my wife was born in Texas and is an alumna of the University of Texas, her father (E. T. Dumble) having been the first State Geologist. My own trip in 1939 from the first of the Southern states, Virginia, to the largest of the Southern states, Texas, was under vastly different conditions from the trip (an account of which has been printed for private circulation) made by my wife's great-grandfather, who in 1835, before Texas belonged to the United States, traveled from Fredericksburg, Virginia, overland by stagecoach to Cincinnati, and thence by steamer to New Orleans and Galveston. My trip to Texas was via Chicago which at the time of great-grandfather was a comparatively small but rapidly growing town in the sparsely settled middle west.

The Leander McCormick Observatory has had other interests in the McDonald Observatory for the reason that one of its Vanderbilt fellows in the nineties was H. Y. Benedict, who was president of the University of Texas and had the chief responsibility for the decision as to the best use to be made of the million dollars that had been left in the will forming the McDonald bequest. As is well known, the heirs contested the will. It seemed possible that they might claim that the donation of so large a sum of money for an astronomical observatory might conceivably be an indication of eccentric behavior, and hence President Benedict put the question to several directors as to whether Leander McCormick, James Lick, Charles T. Yerkes, Andrew Carnegie, and other philanthopists who had given the funds for American observatories had been men of sound or of feeble judgment. (I understand from one of the lawyers of the University of Texas that the question was not raised in the legal proceedings.) A compromise was made in the suit and the sum of approximately $800,000 became available for the new observatory.

The Leander McCormick Observatory has had a long and pleasant connection with the Warner and Swasey Company. In November, 1935, I had the pleasure of a visit from my good friend, Dr. Ambrose Swasey

(when he was nearly 89 years old) on the occasion of the meeting of the National Academy of Sciences at the University of Virginia. When we went together to the observatory, he said, "Mitchell, I have been trying to come to see you for a very long time. The last time I was here was 53 years ago. Mr. Warner and I were a young firm that went to Cleveland in 1882. This was our first big astronomical job. The contract for this dome specified that it should be moved by a pull of one and a half pounds per ton of weight." I replied that the dome was 45 feet in diameter and weighed about 20 tons. He said, "Yes, that is about right, and means a 30-pound pull." I then asked him to move the dome but stipulated that I would permit him to use one hand only. His eyes sparkled with keen delight when he found that the pull required was no greater than could be given by a five-year-old child. He said, "We must have done a fine job a half century ago," and I replied, "You did, and your firm has been doing fine jobs ever since."

William Johnson McDonald had been a banker in Paris, Texas. Little had been known of the fact that he was a lover of the stars until his will was read in 1926 bequeathing a munificent sum "for the purpose of aiding in erecting and equipping an astronomical observatory to be kept and used in connection with and as a part of the University, for the study and promotion of the study of astronomical science." Six years later, when the litigation over the will had been settled, Dr. Otto Struve became the third director of the Yerkes Observatory. He brought it to the attention of President Robert M. Hutchins of the University of Chicago that the Yerkes Observatory needed additional equipment, particularly for astrophysical research, to supplement the 40-inch visual refractor, the largest of its kind in the world, and the two-foot reflector, a Ritchey product that had been the forerunner of the 60-inch and 100-inch reflectors of Mount Wilson. As college administrators can more readily discuss large figures with the dollar sign in front of them than can astronomers (who are entirely familiar with the large figures but without the preface of the dollar sign) it took comparatively little time for the presidents of the Universities of Chicago and Texas to work out a thirty-year plan of coöperation whereby the University of Texas, through the McDonald bequest, should erect and equip the observatory while the University of Chicago should stand three-fourths of the annual cost of maintenance.

On December 31, 1933, the disk of Pyrex for the parabolic mirror was cast at the Corning Glass Works. Several months later when the annealing oven was removed, it was found that the disk had some imperfections. As a result, Dr. Hostetter and Dr. McCauley offered to anneal it for a second time. In this process the 80-inch original casting was stretched in its diameter and became an $82\frac{1}{2}$-inch disk. The mirror is 12 inches in thickness and has a focal length of 320 inches, considerably less than the 390-inch focal length of the Leander McCormick visual refractor. The Virginia telescope which was the largest in the United

States when it was dedicated in 1883, has a ratio of aperture to focal length of 1:15, while the new Texas telescope has a ratio of 1:4. Although the scale on direct photographs for the two telescopes is nearly equal, the McDonald reflector has a light-gathering power ten times that of the McCormick refractor. We say in popular language that the McCormick eye can see stars 10,000 times fainter than can be seen with the naked eye. If the McDonald telescope is ever used for visual observations (which we doubt) it can bring to view stars 100,000 times fainter than can be seen by the unaided eye, or about to the 18½ stellar magnitude.

The arrangements for direct photography with the McDonald reflector are unique in that no provision has been made for a Newtonian focus. Such an arrangement has two draw-backs: (1) the Newtonian flat loses about 20 per cent of the incident light through reflection, and (2) it may cause some slight astigmatism. Instead, photographs are to be made in the prime focus, and the necessary guiding will be done from the rim of the tube by means of an elaborate device designed by G. W. Moffitt and G. Van Biesbroeck. When the 200-inch telescope is completed, there will also be no Newtonian focus, but at Mount Palomar the guiding for photographs at the prime focus will be comparatively simple in principle since the observer himself will be located at the prime focus enclosed in a cage that will obstruct the light falling on the central 60 inches of the 200-inch mirror.

The abolition of the Newtonian mirror with its loss of light will speed up the performance at the prime focus. This will be specially valuable in spectrographic work permitting the photography of the spectra of very faint stars. A slitless spectrograph of novel design will be used. The field is approximately 40′ in diameter and, with a small dispersion of 250 A/mm, the limiting magnitude will be 15 or 16.

Ordinarily the McDonald telescope will be used at the Cassegrain focus where the equivalent focal length is 91 feet (f/13). Two different spectrographs are already in use. The first has a pair of quartz prisms by Bausch and Lomb of 4 inches aperture, the second has a pair of light flint-glass prisms by Gaertner. A camera lens of 20 inches focal length gives a linear dispersion of 50 A/mm at 4000 A with the quartz prisms and a two-fold greater dispersion of 25 A/mm with the glass prisms. Three Schmidt cameras of f/2, f/1, and f/0.5 provide smaller dispersions. It is expected that the limiting magnitude for photographic work with the 50 A/mm dispersion will be about 9.5, while 15th magnitude stars can be reached with the f/1 Schmidt camera.

A third spectrograph will be chiefly for the spectra of stars in the red through the use of two separate gratings, one ruled by R. W. Wood on aluminum deposited on glass, the other by H. G. Gale on speculum metal. Two different cameras will be available, one designed by Moffitt, the other by Ross. The dispersion of the shorter focus will be 80 A/mm.

The low dispersion spectrograph at the Cassegrain focus is to be used

principally by Kuiper for the determination of spectral types and absolute magnitudes. This spectrograph can be quickly taken off the telescope and in its place may be put a large direct camera, or a filar micrometer if it is desired to measure visual double stars.

The mounting of the 82-inch is of the cross-axis type quite similar in form to the Victoria, Delaware, and Toronto telescopes. The declination axis, however, is quite short and stubby, an arrangement that permitted the beam of light to enter the polar axis after two reflections. The Coudé spectrograph at the lower end of the polar axis in a constant temperature room will have prisms made by Hilger of 7 inches in length and 5 inches in width. The effective focal length of the Coudé arrangement is 158 feet (f/23). The dispersion of the present set-up is 3 A/mm, but later by the use of Schmidt cameras and a diffraction grating different dispersions will be provided.

It will be seen from the above that the chief astronomical work planned for the 82-inch is spectrographic rather than direct photography. The McDonald telescope is about midway in aperture between the 60 and 100-inch reflectors of the Mount Wilson Observatory. Evidently it would be unwise for the McDonald telescope to enter into competition with the larger aperture at Mount Wilson in the investigations of faint extra-galactic nebulae which is now so efficiently being done by Hubble, Humason, and Baade. It would be wiser to wait for two or three years until the 200-inch telescope is put into commission.

Unfortunately some of our great American telescopes are located in regions where there is much of cloudy weather and comparatively poor seeing. In order to secure the best conditions possible, the McDonald Observatory was not placed near the campus of the University of Texas at Austin but 500 miles distant in the Davis mountains in southwest Texas. The altitude on Mount Locke is 6828 feet above sea level and about 1500 feet above the level of the surrounding country. The longitude is 104°, or about 7 hours west of Greenwich, and the latitude 30° 40′ N, or closer to the equator than any other large observatory in the northern hemisphere engaged in extensive stellar work. The weather conditions will be quite different from those found in California and will be more nearly like the conditions at the Lowell Observatory. In California from May to November there is much of clear weather with little interference from clouds and rain. In west Texas there are summer rains permitting extensive cattle ranches like the King or Kokernot ranches. In fact, the day of our arrival on the Southern Pacific Railroad at Alpine, we were treated to a violent thunderstorm and a veritable deluge. Things grow large in Texas and the hail stones were of the size of the end of one's thumb. The California observatories have their cloudiest weather in the winter months when, on the contrary, McDonald and Lowell observatories expect fairly clear weather.

The comparatively short focal length of the telescope required a dome only 62 feet in diameter. The dome is fairly unique in that it also houses

the offices of the staff, the library, dark rooms, etc., and living quarters for the younger unmarried astronomers. At a lower altitude than the dome are the residences of the director, the assistant director and two of the astronomers. There is a power house for the generation of electricity and provision for the pumping of water.

The nearest town is Fort Davis about 20 miles away, a distance approximately equal to that which separates the Lick Observatory from San Jose or the observatory on Mount Wilson from its offices in Pasadena. The nearest railroad is another 25 miles away at Alpine.

The optical quality of the 82-inch mirror has been tested by Dr. J. S. Plaskett and C. A. R. Lundin, the maker. Quoting[1] from the former, "No part of the 82-inch mirror, nearly 5000 square inches of glass, is so much as one-millionth of an inch, seven-tenths of one-millionth, to be exact, from the true theoretical form. This is about one-thirtieth of a wave-length of visual light, an indication of the perfection of the optical surface. It is usually considered that a deviation of the wave front of a quarter wave, and hence after the reflection a departure of the mirror surface of an eighth wave should give excellent definition. As the departure of the actual surface is only one-fourth the allowable amount it should and does give superb definition. Further, the specifications called for an image not larger than 0.05 mm, two one-thousandths of an inch, while the actual mean diameter is only one-twelfth this limit. The diameter of a star image photographed with the 82-inch mirror under only average seeing conditions is 0.05 mm, 1.3 seconds of arc. * * * The optical quality is expressed by the smallness of the Hartmann criterion "T," which is simply the mean diameter of the confusion circle in terms of the one hundred-thousandth of the focal length. * * * The criterion "T," the mean diameter of the geometrical image and the magnitude of the aberrations are 2½ times larger in the Victoria mirror, 3 times larger in the Delaware mirror, and 4 times larger in the Toronto mirror (the only large reflectors whose aberrations have been published)."

The permanent staff of the McDonald Observatory will consist of: Dr. Otto Struve, director (also director of the Yerkes Observatory), Dr. C. T. Elvey, assistant to the director and in direct charge when Dr. Struve is absent, Dr. C. K. Seyfert, Dr. Daniel Popper, and Mr. Walter Linke. The astronomers of Yerkes Observatory act as research associates and utilize the McDonald telescope for special problems.

The director reports that a considerable part of the McDonald bequest has not been spent but will be available for future development or for possible independent operation by the University of Texas when the present 30-year contract expires. The directors of other observatories with limited resources will look with envy on Dr. Struve, in these days of financial uncertainties, in that he has some money put away for a possible rainy day.

[1] *Science*, **89**, 495, 1939.

In spite of the isolation and long distances traveled, four hundred people participated in the dedication ceremonies on Friday, May 5. We on the "Astronomers' Special" arrived at Alpine at 2:30 the afternoon before, in time to take part in the joint meeting of the American Astronomical Society and the southwestern division of the American Association for the Advancement of Science. We were the guests at dinner of the Sul Ross State Teachers' College and then listened to an instructive lecture by Dr. A. H. Compton of the University of Chicago on "Physics Views the Future."

The astronomers attending the dedication and the symposium on "Galactic and Extra-Galactic Structure" were: from Europe, Bertil Lindblad, director Stockholm Observatory, E. A. Milne, Rouse Ball professor, Oxford University, and J. H. Oort, Leiden Observatory. From the American observatories were the following directors: W. S. Adams, Mount Wilson, Harlow Shapley, Harvard, Henry Norris Russell, Princeton, W. H. Wright, Lick, H. D. Curtis, Michigan, Joel Stebbins, Washburn, J. S. Plaskett (emeritus), Victoria, J. Gallo, Tacubaya, N. T. Bobrovnikoff, Perkins, Robert R. McMath, McMath-Hulbert, Frederick Slocum, Van Vleck, Jan Schilt, Rutherford, P. van de Kamp, Sproul, Edwin F. Carpenter, Steward, J. J. Nassau, Warner and Swasey, S. A. Mitchell, Leander McCormick; and also the following astronomers: Edwin P. Hubble, Walter Baade, R. J. Trumpler, C. D. Shane, J. A. Pearce, Cecilia Payne-Gaposchkin, Bart J. Bok, Helen Sawyer Hogg, A. E. Whitford, C. E. Hesthal, Horace W. Babcock, together with the host astronomers from McDonald and Yerkes Observatories: Otto Struve, C. T. Elvey, F. E. Ross, G. W. Moffitt, G. P. Kuiper, W. W. Morgan, S. Chandrasekhar, C. K. Seyfert, Daniel Popper, Jesse Greenstein and others.

The details of the scientific papers presented will be given elsewhere, and as a result it will be necessary here to say only a few words. The dedication exercises on Friday, May 5, were divided into three parts, morning, afternoon, and evening. In the morning, three papers were presented, "Recent Advances in Astronomy" by Harlow Shapley but with the discussion confined to various problems connected with variable stars; "Astronomy in Mexico" by J. Gallo with special reference to the Carte du Ciel photographs; and "The 82-inch Telescope" by J. S. Plaskett. At noon the conferences adjourned and on a level place below the observatory, the Warner and Swasey Company had arranged a chuck wagon dinner served to the 400 guests in true cowboy fashion.

The afternoon session was presided over by Dr. Edward Randall, vice-chairman of the Board of Regents of the University of Texas. Mr. C. J. Stilwell, president of the Warner and Swasey Company, formally turned over the keys of the observatory to Dr. Otto Struve, director, who spoke of the chief features of the telescope and the main scientific problems to be undertaken. Dean Henry G. Gale on behalf of President Robert M. Hutchins and then Major J. R. Parthen, chairman of the

Board of Regents of the University of Texas, spoke of the coöperative plan entered into by the two universities. Dr. J. S. Plaskett gave some interesting facts concerning the excellent quality of the 82-inch mirror and Dr. A. H. Compton spoke on "The First of the Sciences." Dr. Homer P. Rainey, president-elect of the University of Texas, concluded his address as follows: "We are here to dedicate this observatory to the most ancient and purest of all the sciences. In doing so, may I express the hope that this observatory will stand as an enduring symbol of the insatiable desire of man to discover the secrets of the universe, and that it may also stand as the symbol of the freedom of man's mind to explore the boundless areas of truth without any restrictions whatsoever." At night we had the opportunity of observing the globular cluster Messier 3 at the Cassegrain focus.

The symposium consisted of a total of sixteen papers, seven presented in three sessions, morning, afternoon, and evening on Saturday, May 6; another seven papers on Sunday, May 7, and two in the morning of Monday, May 8, the conferences being concluded at noon. All of the morning and afternoon sessions were held in the library of the observatory while those in the evening were held at Indian Lodge, a dozen miles away. Each of the papers and the discussion which followed took approximately an hour, some a little shorter and others a bit longer, so that the two days with seven hours of concentrated attention made rather a heavy dose administered for our delectation. However, when one had experienced the delightful hospitality of lunch at one of the homes of the astronomers on Mount Locke and in the evening had dined at Indian Lodge in the company of his astronomer friends, the time went very quickly and most profitably.

On Monday afternoon the tenderfeet from the East were treated to an exhibition of broncho-busting and lassooing on Prude's ranch near Fort Davis. In Texas this western show is known as a ródeo. The astronomers from Arizona and California have frequent opportunities to see what the Californians call a rodéo. The astronomers started homeward on Monday night. On Tuesday those who had come in the two special Pullmans from Chicago were given a 300-mile bus trip from El Paso and also a 5-mile hike through the famous Carlsbad Caverns.

The splendid generosity of the Warner and Swasey Company and the admirable perfection of arrangements for all the multifarious details made the dedication and symposium an occasion of outstanding excellence in the history of astronomy. We shall look forward with great confidence to scientific knowledge of the finest quality that will assuredly be obtained by the director and staff of the W. J. McDonald Observatory of the University of Texas.

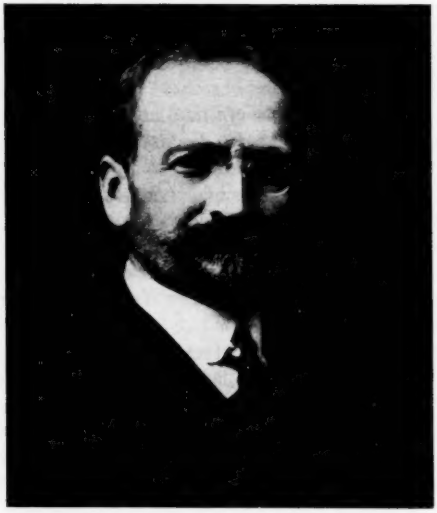
LEANDER MCCORMICK OBSERVATORY, UNIVERSITY, VIRGINIA, OCTOBER 1, 1939

David Todd
1855-1939

An Appreciation

By CHARLES J. HUDSON

David Peck Todd, who for about forty years was intimately associated with Amherst College, died June 1, 1939, at the age of eighty-four years. To many an alumnus of Amherst his passing will mean not only the loss of a friend, a teacher who helped to mold his life, but also a change in the state of affairs which we all become more keenly aware of as we grow older.



DAVID TODD

David Todd was born in Lake Ridge, New York, March 19, 1855. His father, Sereno Edwards Todd, a writer of note, who worked with Horace Greeley, was a direct descendent of Christopher Todd who settled very early in Connecticut on a "plantation" which now includes a part of the Yale University campus, and of Jonathan Edwards, the celebrated early American preacher. He entered Columbia College in New York City with the class of 1874. He stayed there only two years because an opportunity to go to Amherst where the use of an observatory was provided proved too attractive to resist. He graduated, with Phi Beta Kappa recognition, from Amherst at the age of twenty with

the class of 1875. He received the degree of Master of Arts at Amherst in 1878.

While studying at Amherst he made use of the 7¼-inch Clark refractor to observe Jupiter's satellites, particularly the times of their eclipses, and the transit of Venus on December 9, 1874. It happened that Simon Newcomb was also interested in observations of Jupiter's satellites by means of which he hoped to test his theory concerning the change of the rotation period of the earth. Because of Mr. Todd's assiduity in observing all the available eclipses of Jupiter's satellites over a continuous period of several months, Simon Newcomb offered him a position at the U. S. Naval Observatory at Washington. He accepted this offer and was associated with the Naval Observatory until 1881.

It is interesting to look over his notes. In spite of his astronomical bent which later turned to the deepest love for his work he hesitated before accepting the offer from the great Newcomb. He wanted to be an organist. Who, among the readers of this appreciation, has not had the same kind of a decision to make, or cannot look back upon past experiences and wonder if the best conclusion was reached? How appropriate also that a love of music should permeate an astronomer's life.

While in Washington he met Mabel Loomis, daughter of Eben Jenks and Mary Alden Wilder Loomis, whom he married in 1879. Mr. Loomis was an astronomer and mathematician of note, entering the office of the *American Ephemeris and Nautical Almanac* within a year of its establishment by Congress and remaining there continuously for fifty years; he retired in 1900. One daughter, Millicent, was born to Mr. and Mrs. Todd.

Mr. Todd came to Amherst College in the fall of 1881 to accept the offer to become Instructor in Astronomy and Director of the Observatory. From this date until his retirement in 1920 he was the friend of student and townsman alike. While at Amherst his duties and responsibilities grew. He became Associate Professor in 1882, Professor in 1892, was Secretary of the Faculty 1891-1909, and was active on many committees which are always necessary in the successful management of any college.

The transit of Venus in 1874 must have promoted in Professor Todd a strong interest in solar activities of all kinds for it is particularly with relation to the sun that he is best known. Simon Newcomb[1] used Todd's preliminary solutions of equations of Observations of the Transit of Venus, December 9, 1874. This work led to his selection as the Astronomer in charge of Lick Observatory observations of the transit of Venus in 1882 from which expedition excellent photographs were obtained. It is interesting to note in this day of great strides in the field of rapid emulsions on both dry plates and films that Dr. Todd had to use wet plates for photographing the transit of Venus on December 6, 1882.

[1] "The Elements of the Four Inner Planets and the Fundamental Constants of Astronomy" by Simon Newcomb 1885, page 143.

These photographs are likely to remain in a class by themselves for some time, since the next transit of Venus is still sixty-five years in the future.

In the fall of 1882, in addition to his duties at Amherst, he was appointed Professor of Astronomy and Higher Mathematics at Smith College, a position which he held for five years. During this period the Smith College Observatory was erected. He was active in assisting in the design of this building.

At Amherst Professor Todd's observational work was at first carried on at the old Lawrence Observatory. Although the observatory owned a fine Clark refractor of $7\frac{1}{4}$ inches aperture the foundation was not good, and its location was poor. He undertook to raise money for a new observatory and telescope. This was done with the result that an 18-inch Clark refractor with modern mounting was erected together with an excellent building with modern facilities located on a hill a half mile from the college campus. This equipment, with additions, still serves the college for its astronomical activities.

Dr. Todd's life was an extremely active one. He was always busy and managed to thrive on very little sleep—two to four hours each night often being sufficient. He was a prolific writer, a lecturer of note, a great traveller to observe eclipses, and a worker on those parts of astronomy which most interested him. He is perhaps best known for his eclipse expeditions, twelve in all, to all parts of the globe to which he carried observational and photographic apparatus. His first expedition was to Texas in 1878. His last was to Russia in 1914. His second expedition in 1887 to Japan was notable. Although the sky was cloudy and no photographs were obtained he did accomplish the making and testing of an automatic means for taking many photographs with minimum amount of equipment and personnel. He, himself, considered this apparatus one of his greatest achievements. During this expedition the idea occurred to him that it ought to be possible to make many exposures if automatic apparatus could be provided. He built a crude model while in Japan and in the preparatory days just before the eclipse, proved that it would work. He perfected it later until in its final form it was possible to take several hundred photographs during the few minutes of totality without fear of human error resulting from nerve tension during the eclipse. Although the apparatus was ready for use for two subsequent eclipses which turned out to be cloudy, it was not until the eclipse of August 30, 1905, in Tripoli that Dr. Todd was able to prove that his apparatus would work. Several hundred excellent photographs were obtained.

The apparatus consisted essentially of means of inserting photographic plates into position at the focus of any number of instruments, making the proper exposure, covering the plates, removing them and inserting the next plates into position. The original apparatus was constructed to use air at reduced pressure and was operated by means of a small organ-like, foot powered machine equipped with a perforated paper roll similar to those used on a player piano. Each perforation of the

paper roll was responsible for some mechanical movement at one of the telescopes. It was only necessary to provide the proper spacings of the perforations in order to acquire the desired result.[2] Later Dr. Todd changed his automatic apparatus so as to adapt it to the use of electric power. This was done by replacing the pneumatic device with a rotatable cylinder provided with contact points much after the fashion of Swiss music boxes.[3]

All of this work was done before the invention of moving pictures. How much Dr. Todd's accomplishments influenced Edison and others in the years close to 1893 when this topic was the object of much research work may never be known. His work was done with glass plates since the film was hardly known at that time.

His means of driving the polar axis to which most of his instruments were attached is interesting and shows that his mind was active in a mechanical direction. The drive was through a glycerine clock. It consisted essentially of a weight operating against a cylinder of glycerine by means of a piston; the glycerine was allowed to escape at a given rate by controlling the aperture of a valve. This apparatus, though crude was light to carry, efficient and sufficiently accurate to operate satisfactorily throughout the length of totality of any eclipse.

The majority of the eclipses which Dr. Todd journeyed to observe were cloudy or attended by some other misfortune which must have resulted in extreme disappointment. Perhaps it was the thought of these disappointments, lost opportunities over which he had absolutely no control, which, in his last years, unsettled his brilliant mind.

At least one very valuable result, however, came from these eclipse disappointments. He began writing to people located in the path of the next eclipse several years in advance asking them to keep records of weather conditions at their particular geographical locations. From these records astronomers of all countries made their decisions concerning the location most favorable for observations.

During the eclipse of December 22, 1889, Dr. Todd attempted the task of forwarding eclipse information by telegraph along the path of totality. His purpose was to make it possible for astronomers to photograph phenomena for which they were not prepared, but could become prepared for, if they were informed by those astronomers located along the western end of the eclipse track. This attempt is excellently described in "Total Eclipses of the Sun" by Mabel Loomis Todd. In recognition of his success in this work Washington and Jefferson College gave him an honorary Ph.D. degree.

The eclipse of December 22, 1889, was a very important one. Dr. Todd was chosen chief of the United States Scientific Expedition to West Africa. For this expedition the U. S. Steamship *Pensacola* was

[2] "Total Eclipses of the Sun" by Mabel Loomis Todd, First Edition, page 187.
[3] "Automatic Photography of the Sun's Corona" by David Todd, POPULAR ASTRONOMY, Vol. XLI, No. 6, June-July, 1933.

detailed, the order being signed by Admiral George Dewey. His apparatus for automatic photography was brought to perfection for this eclipse and was used even though light clouds were present during the period of totality. The expedition, however, was far from being a complete loss since many technical papers on a number of different scientific topics resulted. Eben Jenks Loomis has described this expedition delightfully in his book "An Eclipse Party in Africa."

To be near Dr. Todd, Percival Lowell moved to Amherst for a short period of time. Because of their mutual interests there were at least three important results. Lowell financed one eclipse expedition to Africa in 1900. The plates obtained became his personal property. He financed a second expedition to Chili in 1907 to obtain photographs of Mars during its close approach of that year. This was known as the Lowell expedition to the Andes. Professor Todd was chief of this expedition when many thousands of photographs were obtained all of which became the property of Percival Lowell. For this work the Amherst 18-inch refractor was transported to the southern hemisphere, the mounting suitably reconstructed for the chosen latitude and the photographs taken with it. The third item of interest which Percival Lowell's contact with Dr. Todd brought about concerned a trans-Neptunian planet in which Dr. Todd had been very much interested.[4] It is easy to believe that Lowell's enthusiasm for this search was acquired from Dr. Todd. He did a considerable amount of computation and search for this planet. Miss Clerke refers to Dr. Todd's labors in her "A Popular History of Astronomy during the Nineteenth Century."

Dr. Todd was mechanically minded. He published several articles of note concerning pieces of apparatus. Aside from his enthusiasm for mechanical photography he became interested in and published articles on devices for revolving a dome, a 100-inch refracting telescope, mechanical attachments to facilitate sweeping in right ascension for equatorial mountings, utilization of the electric telegraph during solar eclipses, construction of high altitude observatories, etc.

He became highly enthusiastic over the possibilities of the airplane for use in photographing total solar eclipses and was one of the early pioneers in such attempts. His interest for aeronautics began as early as 1880 when he worked with Langley in experimental design of airplanes. He made several balloon flights. He had made all arrangements with the Imperial Russian Government for the use of an airplane to observe the eclipse of August, 1914. The outbreak of the World War prevented these arrangements from being carried through. In 1925 he worked in conjunction with the United States Army air service in superintending the first aerial photographs of the solar corona.

[4] Preliminary account of a speculative and practical search for a trans-Neptunian Planet, *American Journal of Science*, Vol. XX, pp. 225-234, September, 1880.
Telescopic Search for the trans-Neptunian Planet, *Proc. of the American Academy of Arts and Sciences* for 1885, X, pp. 228-243.

The possibilities of the use of the airplane to get above the clouds in case of cloudy weather during an eclipse had been strongly brought home to him. He was one of the founders of the Aero Club of America, a member of the Board of Governors of the Aerial League of America and of the Board of the National Advisory Association of Aeronautics. In 1908 he founded the Amherst Aero Club, the forerunner of one of the several present day college flying clubs.

Dr. Todd was a member of many societies which include fellowship in the American Association for the Advancement of Science, American Astronomical Society, Washington Philosophical Society, Astronomische Gesellschaft, Sociedad Geográfica de Lima, Peru, and others. He was honored by the Emperor of Japan in 1896 by the presentation of the Imperial Saké Cup for his services in the interest of education in northern Japan during the Amherst Eclipse Expedition period of that date.

The writings of Dr. Todd were many and varied, from technical publications to magazine articles in the popular style of easy astronomical reading. He had a way of making astronomical problems clear and simple to the layman. A complete list of his publications cannot be given here. As a writer he is perhaps best known as the author of the textbook "New Astronomy" which passed through twenty-five editions, was translated into a number of foreign languages and was for many years a standard college textbook for use in courses of astronomy. Although sadly in need of revision to bring it up to date it is still in demand today. He was editor of the Columbian Knowledge Series which began publication in 1893. Webster's New International Dictionary employed him as astronomical and mathematical editor and he was a contributor in the Encyclopaedia Britannica with a treatise upon "Telescopic Work in America." His "Continuation of de Damoiseau's Tables of the Satellites of Jupiter to the year 1900" published for the *American Ephemeris and Nautical Almanac* was one of his important early papers.

A year of residence was spent in Observatory House at Amherst by the writer. It was a most enjoyable one. Professor Todd's astronomical enthusiasm was completely shared with the members of his family, Professor Loomis, Mrs. Todd, and Millicent Todd (now Mrs. Walter V. Bingham). They, in turn, were a source of inspiration to him, for each in his own name had a right to an enviable reputation in the literary field as well as in others. Rarely does a family exist where all are so completely successful. Someone, someday should record the accomplishments of this illustrious family.

In closing let me repeat the words of Alfred E. Stearns in the Amherst Graduates Quarterly, "David Todd was very much a pioneer. In many respects he was years ahead of his time . . ."

West Boylston, Massachusetts, August 20, 1939

The Calculation of Meteor Orbits

(TABLES)

By C. C. WYLIE

In an earlier paper[1] we stated that tables had been computed to make the calculation of meteor orbits less laborious. These tables include the following: the velocity of the earth in its orbit, the direction of the earth's motion, the geocentric velocity, and the zenith attraction. The notation is that of the preceding paper.

THE VELOCITY AND DIRECTION OF THE EARTH'S MOTION

The velocity of the earth in its orbit can be calculated from the formula

$$V_1 = k\sqrt{(2/r) - 1}$$

If V_1 is measured in miles per second, k is equal to 18.4957. Taking the value of r from the *Ephemeris* for 0^h Greenwich civil time on the first of each month, the corresponding value of V_1 was computed. This was done for several different years, and the variation from year to year was found to be less than 0.01 mile, a negligible quantity in meteor work.

The direction of motion of the earth at any time is that of the tangent to the orbit. By differentiation it was found that the deviation of the slope of the tangent from that of a circle is

$$\Delta(-\cot v) = \csc^3 v\, \Delta v = e/\sin v$$

whence

$$\Delta v = e \sin v$$

Expressing in minutes of arc

$$\Delta v' = 57'.53 \sin v.$$

If the orbit of the earth were a circle, the direction of motion at any time would be the direction of the sun at a longitude 90° different. The actual direction of motion of the earth at any time T is that of the sun from the earth when its longitude is $(90° + \Delta v)$ less than its longitude at the time T.

Using Ephemeris values for the mean longitude of perihelion, and for the longitude of the sun, the value of v was obtained for 0^h Greenwich civil time on the first of each month. From this value of v, Δv was computed, and then $90° + \Delta v$. The latter quantity is denoted by ΔL. Calculations for different years showed that, in general, the variation of ΔL is less than a minute of arc, an insignificant difference.

Table I gives for 0^h Greenwich civil time on the first of each month the velocity of the earth in its orbit V_1, and the quantity ΔL. The velo-

[1] The Calculation of Meteor Orbits (Formulas), POPULAR ASTRONOMY, p. 425, October, 1939.

city is read directly from the table. The right ascension and declination of the apex of the earth's motion are obtained as follows. Take the longitude of the sun from the *Ephemeris* for the time of fall of the meteor. From this longitude subtract the quantity ΔL. Then from the *Ephemeris* take out the right ascension and declination of the sun for a time about three months earlier, when it had exactly that longitude. These are the coördinates of the apex of the earth's motion.

TABLE I

Date	V_i	ΔL	Date	V_i	ΔL
Jan. 1	18.81	89° 58′	July 1	18.19	90° 3′
Feb. 1	18.77	90 28	Aug. 1	18.22	89 35
Mar. 1	18.66	90 49	Sept. 1	18.33	89 12
Apr. 1	18.51	90 58	Oct. 1	18.48	89 3
May 1	18.35	90 51	Nov. 1	18.63	89 8
June 1	18.24	90 30	Dec. 1	18.76	89 28

The Zenith Attraction

The formulas for zenith attraction are:

$$w^2 = u^2 + V_i^2$$

and

$$\tan(\Delta z/2) = M \tan(z/2)$$

where

$$M = (w-u)/(w+u)$$

Including the correction for the centrifugal force of the rotating earth, the value of V_i for an ending 20 miles above mean sea level is 6.924 miles per second. Using this value of V_i, the corresponding values of $w-u$ and M were calculated for values of w varying from 7 miles per second to 45 miles per second. The resulting values are given in Table II.

To obtain the geocentric velocity and radiant from Table II, the procedure is as follows. With w as argument, take out the corresponding value of $w-u$, and subtract from w. The result is u, the geocentric velocity.

With w as argument take out the corresponding value of M. On a slide rule or otherwise, multiply M by $\tan(z/2)$. The result is $\tan(\Delta z/2)$. By adding Δz to z, the zenith distance of the geocentric radiant is obtained. The azimuth of the geocentric radiant is the same as the azimuth of the apparent radiant.

TABLE II

w	$w-u$	M	w	$w-u$	M	w	$w-u$	M
7.0	5.97	.7437	7.7	4.33	.3913	8.4	3.64	.2770
			7.8	4.21	.3695	8.5	3.57	.2658
7.1	5.53	.6376	7.9	4.10	.3500	8.6	3.50	.2554
7.2	5.23	.5696						
7.3	4.99	.5188	8.0	3.99	.3325	8.7	3.43	.2457
						8.8	3.37	.2367
7.4	4.79	.4783	8.1	3.90	.3167	8.9	3.31	.2283
7.5	4.62	.4447	8.2	3.81	.3023			
7.6	4.47	.4161	8.3	3.72	.2891	9.0	3.25	.2204

TABLE II (CONTINUED)

w	$w-u$	M	w	$w-u$	M	w	$w-u$	M
9.1	3.20	.2129	12.7	2.05	.0879	21.0	1.17	.0288
9.2	3.14	.2059	12.8	2.03	.0863	21.5	1.14	.0274
9.3	3.09	.1993	12.9	2.02	.0848	22.0	1.12	.0261
						22.5	1.09	.0249
9.4	3.04	.1931	13.0	2.00	.0832			
9.5	3.00	.1872				23.0	1.07	.0237
9.6	2.95	.1816	13.1	1.98	.0817	23.5	1.04	.0227
			13.2	1.96	.0803	24.0	1.02	.0217
9.7	2.91	.1762	13.3	1.94	.0789	24.5	1.00	.0208
9.8	2.86	.1712						
9.9	2.82	.1664	13.4	1.93	.0775	25.0	0.98	.0200
10.0	2.78	.1618	13.5	1.91	.0762	25.5	0.96	.0191
			13.6	1.89	.0749	26.0	0.94	.0184
10.1	2.75	.1574				26.5	0.92	.0177
10.2	2.71	.1532	13.7	1.88	.0736			
10.3	2.67	.1492	13.8	1.86	.0724	27.0	0.90	.0170
			13.9	1.85	.0712	27.5	0.89	.0164
10.4	2.64	.1454				28.0	0.87	.0158
10.5	2.61	.1417	14.0	1.83	.0700	28.5	0.85	.0152
10.6	2.57	.1382						
			14.1	1.82	.0689	29.0	0.84	.0147
10.7	2.54	.1348	14.2	1.80	.0678	29.5	0.82	.0142
10.8	2.51	.1316	14.3	1.79	.0667	30.0	0.81	.0137
10.9	2.48	.1285				30.5	0.80	.0132
			14.4	1.77	.0656	31.0	0.78	.0128
11.0	2.45	.1255	14.5	1.76	.0646	31.5	0.77	.0124
			14.6	1.75	.0636			
11.1	2.42	.1226				32.0	0.76	.0120
11.2	2.40	.1198	14.7	1.73	.0626	32.5	0.75	.0116
11.3	2.37	.1172	14.8	1.72	.0617	33.0	0.73	.0112
			14.9	1.71	.0608	33.5	0.72	.0109
11.4	2.34	.1146						
11.5	2.32	.1121	15.0	1.69	.0598	34.0	0.71	.0106
11.6	2.29	.1097				34.5	0.70	.0103
			15.5	1.63	.0556	35.0	0.69	.0100
11.7	2.27	.1074	16.0	1.58	.0518	36.0	0.67	.0094
11.8	2.24	.1051	16.5	1.52	.0484	37.0	0.65	.0089
11.9	2.22	.1030				38.0	0.64	.0084
			17.0	1.47	.0453			
12.0	2.20	.1009	17.5	1.43	.0425	39.0	0.62	.0080
			18.0	1.38	.0400	40.0	0.60	.0076
12.1	2.18	.0988	18.5	1.34	.0377	41.0	0.59	.0072
12.2	2.16	.0969				42.0	0.57	.0069
12.3	2.13	.0950	19.0	1.31	.0356			
			19.5	1.27	.0337	43.0	0.56	.0066
12.4	2.11	.0931	20.0	1.24	.0319	44.0	0.55	.0063
12.5	2.09	.0913	20.5	1.20	.0303	45.0	0.54	.0060
12.6	2.07	.0896						

UNIVERSITY OF IOWA, JULY 13, 1939

The Light Curves of Novae

By DEAN B. McLAUGHLIN

(Continued from page 419.)

The Pre-Nova Stage

Owing to their large range of magnitude, to the fact that few novae become brilliant naked-eye objects, and to the limit of systematic photography of the sky at about the fifteenth magnitude, we know the pre-nova brightness of relatively few of them. In Table III the data on pre-nova constancy or variation are given for all stars for which the material appears to be conclusive. The table does not include all novae which have been photographed prior to outburst, but only those for which the observations appear sufficient to show constancy, variation, or invisibility over a period of years for those stars whose minima are probably just beyond the limit of the photographs. Inspection of the fourth column shows about as many demonstrated variables as constant stars. As for the invisible ones, we can only say that they have experienced no variation sufficiently great to bring them above the plate limit. As a differ-

TABLE III

Magnitudes of Novae before Outburst

Nova	Year	Magnitude	Var. or Const.	Authority
Aql	1899	<14.7	invisible	H.A. 84
Aql	1918	10-11	variable	H.A. 81
T Aur	1891	<13.7	invisible	H.A. 84
Cir*	1906	14.6-15.0	suspected*	H.A. 84
Cyg	1920	<16	invisible	A.N. **211**, 403
Gem	1903	<14.4	invisible	H.A. 84
Gem	1912	Note 1	constant?	H.A. 84
DQ Her	1934	14-15**	variable	Obs. **58**, 30
Lac	1910	13.5-14.0	suspected	H.A. 84
CP Lac	1936	15.3±0.3	suspected	H.B. 904
Mon	1918	15.1	Note 2	H.A. 84
RS Oph	1933	10.2-12.6	variable	H.A. 84
Per	1901	12.8-13.8	variable	H.A. 84
RR Pic	1925	12.7	constant	Cape **10**
T Pyx	1920	13.6	constant	H.A. 84
Sgr	1898	<16.0	invisible	H.A. 84
Sgr	1899	14.8-15.0	constant	H.A. 84
Sgr	1910	16.4-16.5	constant	H.A. 84
X Ser	1903	14.2-15.4	variable	H.A. 84

*The small range of this nova from minimum to maximum may indicate that the observations at minimum refer to a companion, and not to the nova.

In *Observatory*, **58, 30, 1935, the pre-nova variation of Nova Herculis is given as 14.2-15.4. Later (*Ibid.*, p. 76) it is referred to as 11.0-14.6. The source of the observation 11.0 is not stated.

Note 1. Harvard observations show Nova Gem 1912 <13.8. A Heidelberg photograph shows it as about 15th magnitude.

Note 2. Only one plate (in 1901) shows Nova Mon before outburst. No other plate has an equally faint limit.

ence of at least nine magnitudes between the observed maximum and the faintest plate limit was made a requirement for admission to the list, it is believed that the possible variations of these invisible objects were less than two magnitudes.

Our statistics are quite incomplete, but the general conclusion that a large percentage of novae are slightly variable before outburst appears to be indicated. Probably there are several stars, besides those listed above, for which material is available, but which have not been sufficiently investigated.

The Initial Rise

Statistics of ranges of magnitude will be discussed later. We note here the result that the average range from minimum to maximum is approximately eleven magnitudes. According to its definition, the initial rise must then be about nine magnitudes in the average case. Our present concern is chiefly with the time occupied by this stage. In many cases we know only that observations made within one or two weeks before the nova was found bright fail to show it within several magnitudes of maximum. Obviously this is evidence of a negative kind and can only furnish *upper* limits to the time interval. But there are several well-authenticated cases in which the observations are more conclusive. These are listed in Table IV.

TABLE IV

The Duration of the Initial Rise

Nova	Year	Increase from M	Increase to M	Duration days	Class*
Aql, No. 3	1918	10.5	1.0	2	Fast
Aql, v356	1936	<16	9.5	2	Slow
T Aur	1891	<12	5.4	2	Slow
Cyg, No. 3	1920	7.0	3.5	4	Fast
Gem, No. 2	1912	11.7	4.6	1.0	Fast
CP Lac	1936	15	4	1	Fast
Lyr	1919	<16	6.5	2	Fast
Per, No. 2	1901	<11	2.7	1.3	Fast
Sgr	1936.32	<12.7†	7.5	2	Slow

*Fast and slow refer to the post-maximum behavior, and not to the rate of increase.

†This is the combined light of the nova and a very close companion. As this is approximately the magnitude of the K-type companion alone, it shows that the nova was probably <14.

So far as the duration of the initial rise is concerned, there is no evident difference between slow and fast novae; three slow novae have increased through several magnitudes in two days or less. No other data are known to the writer. Misinterpretations of observations, which resulted in erroneous statements concerning slow increases of light, were dealt with in an earlier section. The ambiguous case of Nova Cygni 1920 has also been discussed. There is at least the possibility that this star had a rapid rise through nine magnitudes before the first observation was obtained, and that the *final* rise was unusually high. Aside from

stars of the RT Serpentis type, no positive observation of a slow initial rise exists. Our slowly rising nova, taking weeks or months to struggle up from obscurity, is a myth based upon the unwarranted backward extrapolation of the *final* rise.

The Pre-Maximum Halt

It was mentioned earlier that the pre-maximum halt may be completely slurred over by a very fast nova. It requires a closely spaced series of observations to show it, but it is well established for several stars which are listed in Table V. Two doubtful examples are included because they show changes of rate of increase at a magnitude corresponding roughly to the halt.

TABLE V

The Pre-Maximum Halt

Nova	Year	Duration of halt, days	Magnitudes below max., Δm	Character of halt
Aql, No. 3	1918	0.2	2.2	pause or decline
Aql, v356	1936	5:	1:*	decline 0.8 mag.
T Aur	1891	3:	1.2*	nearly constant
Cyg, No. 3	1920	0:†	1.5	inflection?
Gem, No. 2	1912	0:†	1	abrupt slowing of rise
DQ Her	1934	1.5:	1.8	decline 0.5 mag.
Oph, No. 4	1919	5:	1.8	decline? 0.2 mag.?
RR Pic	1925	40:	2:	probable decline >1 mag?
Scorpii	1906	30:**	2.3	decline 0.5 mag.

*Probably the true principal maxima of v356 Aql and T Aur were unobserved, as gaps in the series of observations occur at the times the maxima would be expected from analogy with other novae. The correct figures for Δm could easily be about 2.0 magnitudes in both cases.

†Doubtful.

**Possibly this is a minimum between two maxima of Nova Scorpii. The long gap in the series of observations admits the possibility that the principal maximum of light was missed.

Although the initial rise shows no marked distinction between slow and fast novae, the pre-maximum halt reveals well-marked differences. Nova Aquilae 1918 is the only very rapid nova for which the existence of the halt is established. The slow novae may remain for days or even weeks before completing the increase to maximum. All seven of the bright novae of the twentieth century were discovered at the pre-maximum halt or at the magnitude corresponding to its normal position. Nova Pictoris came very near being an exception; it had possibly completed a magnitude or so of its final rise when it was discovered. Thus, with one exception, every bright nova of recent years has been discovered very nearly at the earliest possible moment.

The Final Rise

A fast nova takes about as long to increase through the last two magnitudes as it did to complete the initial rise. A slow nova, on the other hand, takes much longer. The duration of the final rise is given for a number of novae in Table VI.

TABLE VI

THE FINAL RISE

Nova	Year	Duration days	Notes	Reference
Aql, No. 3	1918	1.5		H.A. 81
Aql, v356	1936	8:	possibly 10 days	P.A. **45**, 219
T Aur	1891	5:		H.A. 84
Cir	1906	20:	perhaps secondary max.	H.A. 84
Cyg, No. 3	1920	2.5		H.B. 890
Gem, No. 2	1912	3		H.A. 76
DQ Her	1934	7		M.N. **95**, 538
CP Lac	1936	1.4*	no observed halt*	
Oph, No. 2	1848	10		GuL, I, 2, 438
Oph, No. 4	1919	15:		PASP, **33**, 190
Per, No. 2	1901	1.5*	no observed halt*	H.A. 48
RR Pic	1925	14+		Cape An, **10**
Sco	1906	35	perhaps secondary max.	H.A. 84
XX Tau	1927	5*	no observed halt*	H.B. 856

*In these cases, when no halt was observed, the interval given is that of the rise through the last two magnitudes to maximum.

As noted in the table and in previous sections, the observed increase of Nova Circini and Nova Scorpii may belong to a second maximum rather than the principal one. The slow novae are easily distinguished in this table by their very leisurely increase. Among the rapid ones, Nova Geminorum 1912, Nova Cygni 1920, and XX Tauri 1927 have the longest well-determined final rises. This part of the curve is apparently smooth in all novae, both slow and fast; there are no proven cases of marked fluctuations during the final rise. There is too obvious a period of one day in the supposed rapid fluctuations of Nova Herculis to regard them as certainly real, as contrasted with subjective effects depending on the orientation of the field.

THE MAXIMUM

Every well-observed typical nova has shown a *principal maximum* of relatively brief duration at the end of the final rise. Apparent exceptions arise from incomplete series of observations, as in the case of v356 Aquilae 1936. That star rose from magnitude 9.5 to 8.0; then a ten-day gap occurred in the series, and the next observation showed the star had declined to 8.9. Analogy with other novae suggests that it may have reached the seventh magnitude about the middle of the unobserved interval. The brightest *observed* maximum came about a month later, and the spectrum at that time showed a well-advanced *post-maximum* stage.

A few novae have shown a second and even a third maximum almost equal to the first. In the two cases of which we have detailed spectrographic records (Nova Geminorum 1912 and Nova Pictoris), the spectrum does not show features which should be regarded as indicating an independent second outburst. The development of the spectra of both these stars followed the normal course.

What little we know of the RT Serpentis stars indicates that their light maxima are characteristically flat or broadly rounded and of long dura-

tion,—several years in the type star. The decline from maximum is relatively abrupt for the first one or two magnitudes.

Several typical novae have dropped very rapidly just after maximum light. Nova Aquilae 1918, during an unobserved interval of several hours, faded more than a magnitude. Nova Geminorum 1912 and Nova Herculis declined about two magnitudes at a rate considerably greater than the final rise, and the rate of fading of Nova Pictoris just after maximum was about equal to that of the increase. These cases of steep decline are chiefly confined to the slow novae which show marked oscillations during the "early decline." Nova Geminorum and Nova Aquilae are the only rapid stars which have exhibited this effect.

No statistics of duration of maximum need be presented; it is a matter of hours at the most for fast novae, and not more than a few days for the slow ones.

The Early Decline

In the preceding section a few remarks were made on the beginning of the decline of light. The "early decline" is defined as that portion of the curve from maximum to about 3.5 magnitudes below it. Two kinds of curves may be recognized in this stage: (a) smooth, and (b) irregular.

(a). *Smooth curves.* All the very rapid bright novae have shown a smooth early decline. Nova Persei 1901 and Nova Lacertae 1936 are typical. XX Tauri 1927 is a good example of a somewhat slower nova with a smooth curve, and among the true slow novae we find Nova Normae 1893 and X Serpentis as the only established cases.

(b). *Irregular curves.* The most rapid novae exhibit no definite fluctuations during the early decline. Nova Geminorum 1912 is the most rapid nova in the irregular category. Slow novae with conspicuous fluctuations of one to two magnitudes are quite common. Among these we may cite Nova Herculis, Nova Pictoris, and v356 Aquilae (1936) as typical. There is little if any regularity in the intervals between the subordinate maxima.

The discussion of statistics of the rates of decline will be deferred to a later section. We shall state here, in anticipation of that discussion, that there is no discontinuity between slow and fast novae when we examine the distribution of time intervals required to decline through any given number of magnitudes.

The Transition

When a nova has faded to about 3.5 magnitudes below maximum it will probably do one of three things, as enumerated earlier.

(a). Strong fluctuations with a rough period of several days may set in, as in Nova Persei 1901 and Nova Aquilae 1918 (Figure 4). The manner of beginning of the oscillations was the same in both cases: their onset involved *an abrupt fading of the star below the smooth extension*

of the early decline. This is emphasized in order to point out its resemblance to the deep minimum of Nova Herculis. The oscillations continued for a couple of months and finally ceased almost as abruptly as they had begun. The manner of cessation was the same in both cases: the light failed to brighten from a minimum. Both stars came out of the oscillatory stage *six magnitudes fainter than maximum.* Unfortunately there are no other well-observed novae which have shown such strong fluctuations. Nova Pictoris had a few spasmodic fadings at the corresponding part of its curve, and Nova Geminorum 1912 showed long gentle swells.

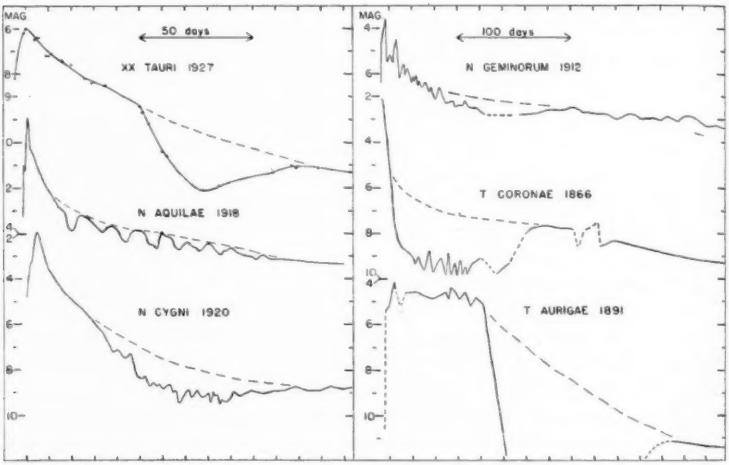


FIGURE 4

LIGHT CURVES OF NOVAE,
showing different types of behavior during the "transition."

(b). A broad minimum of very different depth in individual cases may set in quickly. Among the moderately rapid novae which showed this characteristic, XX Tauri (Figure 4) is a fine example. For two months the star was fainter than the smooth continuation of its early decline. At its deepest the minimum was 2.5 magnitudes below the smooth curve. Eventually a recovery of light placed it on the curve again at just *six magnitudes below maximum.*

Nova Herculis furnished a particularly spectacular example of this type of behavior. During April, 1935, it faded from the fifth to the thirteenth magnitude; during May and June it was recovering; finally it levelled off just about *six magnitudes below maximum.* Similar behavior characterized T Aurigae 1891 (Figure 4) and the recent Nova Sagittarii 1936.32.

Shallower minima, particularly when they are superimposed on a

rapidly dropping light curve, are more difficult to recognize. Nova Cygni 1920 (Figure 4) suffered such a decline which set in so gradually that it appeared to be a mere steepening of the curve. Then the decline rather abruptly stopped and the star fluctuated through a small range. At the end of this stage it was seven magnitudes below maximum.

A marked example of this type of behavior among the fast novae was T Coronae (Figure 4). Its drop to a deep minimum appeared to be a mere steepening of the curve, but the recovery carried it to about *six* magnitudes below maximum. The minimum would have been even more spectacular were it not for the dominant effect of the light of the M-type companion star when the nova was faint.[5] Because this deep minimum and recovery were simply an exaggeration of effects found in the light curves of other novae, the writer is unable to consider T Coronae as a distinct type.

(c). There are some novae which simply show a rather quick change of the light curve towards gentler slope. This appears to be merely a limiting case of (b), a minimum with recovery. This is well illustrated by Nova Cygni 1920, which is a border-line case between (b) and (c). If its drop below the smooth curve had been smaller and had lasted a little longer, the effect would have been simply that of a decreased slope. Other examples which truly illustrate case (c) are Nova Lacertae 1936, Nova Lacertae 1910, Nova Aquilae 1905, and Nova Sagittarii 1898.

Whatever a nova does at 3.5 magnitudes below maximum, it will "snap out of it" at about six magnitudes below, even if it has to stage a remarkable "comeback" to do so. The oscillations set in with a quick decline of light; in this respect they are identical in nature with the deep minimum. There seems to be no good reason for regarding the three manifestations (a), (b), and (c) as really different in any other than a superficial way.

Regardless of which type of behavior a nova exhibits, the stage of the light variation here designated the transition is coincident with the development of the nebular stage of the spectrum. The star enters the transition with a spectrum consisting of the remnants of emission bands and absorption-line systems which first developed around and after maximum light; it emerges from the transition with the absorption spectra vanished and the nebular emission bands well developed.

The Final Decline

The remainder of the fading of a nova is without special features. Small fluctuations of light may occur, but in many cases their reality is questionable. In several novae a steepening of the decline is apparent, as for instance in Nova Lacertae 1910 and Nova Persei 1901. The first example, however, is possibly due mainly to the end of the transition;

[5] Humason, *Aph. J.*, **88**, 234, 1938, suggests this interpretation, which is supported by observations of the spectral changes during an increase of about one magnitude in July, 1938.

the latter is not to be explained in that way. The most conspicuous example of all is Nova Geminorum 1912. These features will be evident from an examination of the several curves in Figure 5, where the time

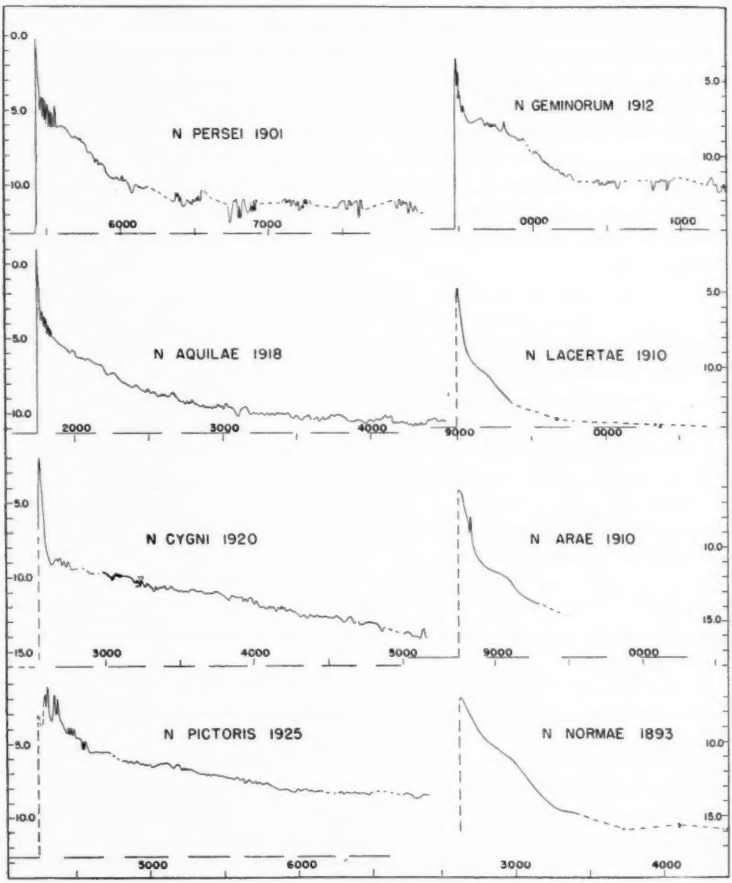


FIGURE 5
"COMPLETE" LIGHT CURVES OF NOVAE.
All are plotted to the same scale. The steepening of the curve during the final decline is brought out.

scale is so shortened as to display almost the entire light curves, except in the case of Nova Pictoris which, at the date of writing, is still much brighter than its pre-nova magnitude.

If any one of the curves displayed in Figure 5 deserves to be called "abnormal" it is that of Nova Cygni 1920. The very rapid decline from

maximum contrasts sharply with the much slower rate of fading after the transition. There is some ground for suspicion that in this case the transition lasted longer and ended at a fainter magnitude (relative to maximum) than in most of the fast novae.

The two slow novae whose curves are shown in Figure 5 are of contrasting types. Nova Pictoris shows almost continuous upward concavity, except for an apparent steepening at the end of the transition. Nova Normae, on the other hand, declined rather uniformly through four magnitudes and then increased its rate of fading very conspicuously and held to the faster rate until it was close to its final magnitude. If we were to classify Nova Normae on the basis of the time required to reach minimum, we should call it a fast nova; but its earlier decline stamps it as a slow one.

The duration of the final decline is greater than that of all the preceding stages together. Even the most rapid novae take several years to reach their pre-nova magnitudes. The shortest recorded time from maximum to minimum is about four years (Nova Sagittarii 1899 and Nova Lacertae 1910). The longest time for a fast nova is that of Nova Persei 1901,—about 15 years. In this case, however, it is probable that the observed magnitude in the later stages represented the integrated light of the star and the bright nebulosity erupted from it. In most novae the nebulous shell fades away within a few years, so that its effect on the duration of the decline is probably not great. Nova Persei was a marked exception, in that the nebula was still conspicuous a third of a century after maximum. The average duration of decline of six well-observed fast novae (including Nova Persei) is about eight years.

The duration of decline shows a large scatter among the slow novae. The recorded interval for Nova Ophiuchi No. 2 (1848) was about 30 years, and for T Aurigae, about 15 years. The records are very incomplete in other cases, and the two best-known slow novae have not yet had time to reach minimum. Nova Circini 1906 took only about six years to reach minimum, but its range was only five magnitudes, and it is almost certain that the star observed at minimum is really an unresolved companion and not the nova at all.

The two repeating novae, RS Ophiuchi and T Pyxidis, at their best-observed outbursts, took respectivly about 100 and 250 days to reach minimum. The apparently quick return of T Coronae to minimum (*after* its recovery following the transition) is probably to be explained by the fact that the observed minimum refers to the M-type companion and not to the nova.

The Post-Nova Stage

After reaching the pre-outburst brightness, several novae have remained irregularly variable for some years, though the indications are that some eventually settle down to constancy. Nova Persei 1901 and Nova Ophiuchi 1848 are the most conspicuous examples of post-nova variation.

A comparison of the brightness of novae before and after the outburst is of interest. A number of these objects which are not found on earlier photographs have been followed long enough to be fairly sure that they have reached a steady brightness, but except for confirming the fact that they are now definitely fainter than the limit of the pre-outburst plates, they give us no positive information. There are several, however, which were recorded before outburst, and for which we have post-nova magnitudes. These are listed in Table VII.

TABLE VII

MAGNITUDES OF NOVAE BEFORE AND AFTER OUTBURST

Nova	Year	Magnitude before	Magnitude after	Difference Magn.
Aql	1918	10-11	10.8	0:
Cir*	1906	14.9*	14.8*	—0.1*
Gem	1912	15:	14.7	—0.3:
Lac	1910	14.0	14.4	+0.4
RS Oph	1933	11.0†	10.5-12:	0:
Per	1901	12.8-13.8	11.8-14.0	0:
T Pyx	1920	13.6	13.6	0.0
Sgr	1899	14.9	14.9	0.0
Sgr	1919	14.0	14:	0:
GR Sgr	1924	16.6	16.5	—0.1
v441 Sgr	1930	16.0	15.5	—0.5

*The recorded minimum is probably the magnitude of an unresolved companion.

†Constant for several years before outburst; previously variable.

The recorded differences in the last column are only such as we might expect from errors of observation, coupled with possible variation of light both before and after the nova episode. There is thus every reason to believe that, given sufficient observations before and after outburst, the average magnitudes should agree. In this connection it is important to note an erroneous statement which has been quoted in various places. Nova Geminorum 1903 is said to have varied through a range of 2.4 magnitudes before outburst, and to be considerably fainter now than it was previously. This is not true. Nova Geminorum 1903 was not recorded on any photograph before outburst; the supposed variation results from the misinterpretation of the recorded magnitude limits of plates which did not show the star. Its *observed* post-nova magnitude is considerably fainter than the faintest plate limit before outburst.

The list given in Table VII could probably be extended very considerably by an examination of recent plates showing novae for which the published material is incomplete. It would also be of interest to examine a number of novae which are now at minimum light for persistent variations like those of Nova Persei 1901, Nova Ophiuchi 1848, and T Coronae.

It should be remarked that observations of novae in their post-nova stage will be most reliable if made systematically with one camera (or similar cameras), or,—for visual observations,—by a few intensely in-

terested individuals. Curves based upon the combination of occasional estimates by numerous casual observers may be very uncertain. The reason lies partly in the very blue color of the star; different observers, using telescopes of different chromatic correction, and having eyes of different sensitivity, will produce a spurious scatter of the data from which the true variations can be disentangled only with great difficulty if at all. An additional source of trouble is the enveloping nebulosity. Telescopes of different power will integrate the star and nebular radiation differently, with consequent systematic differences in the estimated magnitudes.

Unusual Light Curves

The preceding sections have dealt with the characteristics of the light curves of typical novae,—both fast and slow. Not all stars definitely assignable to the nova class exhibit curves which satisfy the specifications implied in the description of the several stages, but the number of exceptions is so small that we shall be able to notice all of them. We consider them under three headings: (1) the "permanent novae"; (2) the RT Serpentis stars; (3) irregular curves. The repeating novae are not considered peculiar, since their individual outbursts have shown no special abnormalities.

The "Permanent Novae"

In the front rank of unusual novae we place P Cygni. First seen in 1600 as a third magnitude star, it showed two maxima at the third magnitude, from 1600 to 1606 and 1657 to 1659. The minima following these maxima were probably about the sixth magnitude. Finally it increased to magnitude 5.2, where it remained from 1715 to the present time. Its spectrum is now in a relatively early post-maximum stage.

The other star in this group is η Carinae, which was first noted by Halley as a fourth magnitude object in 1677. It fluctuated between that brightness and the second magnitude until early in the 19th century. In 1827 it reached first magnitude, and in 1838 there was a well-defined maximum at $0^{M}.2$. The brightest recorded magnitude,—0.8, was noted at another sharp maximum in 1843. From that time until 1856 it was between 0 and +1. It then began a very steady decline which stopped abruptly at $7^{M}.0$ about 1869. Since then it has faded to the eighth magnitude, though it recovered a little in 1889. During the recovery its spectrum was cF5, with emission lines, but when it faded its absorption spectrum disappeared. Its spectrum now consists chiefly of emission lines of hydrogen and iron,—especially the forbidden lines of the latter. In this it resembles the RT Serpentis stars and some typical slow novae during their decline.

The RT Serpentis Stars

A light curve of RT Serpentis is given on page 263 of "Variable Stars" by Payne-Gaposchkin and Gaposchkin. Until rather recently this star was regarded as unique. After a relatively quick rise to the

eleventh magnitude in 1909, the star rose very slowly to maximum and remained there (at $10^{M}.6$) from 1918 to 1923. During the next four years it declined below twelfth magnitude, since when it has faded slowly, with fluctuations, to the thirteenth.

The characteristic features of this curve can be recognized in a few other stars, some of which have not been universally accepted as novae. It is also of interest to note that three objects in the Andromeda spiral are doubtless of this type. The list of galactic novae tentatively assigned to the RT Serpentis class follows.

TABLE VIII

RT SERPENTIS STARS

Nova	Year	Remarks
DO Aql	1925	very slow nova
Ari No. 1	1854	doubtful, few data
Ori*	1939	certain
Sgr (Innes)	1912	probable
Sgr (Innes)	1914	probable
BS Sgr	1917	probable
RT Ser	1909	prototype

*Wachmann's peculiar variable.

DO Aquilae is included on the basis of the form of its curve and the spectral changes, which resemble those of RT Serpentis. However, its progress was more rapid than that of the type star; indeed, it seems to occupy a place intermediate between the typical slow novae and the RT Serpentis stars.

Nova Orionis 1939 has been valuable in fixing the rate of increase of light. There is no doubt that these stars rise from obscurity much more slowly than the typical slow novae. Nevertheless, relative to the later changes, the rise is very rapid and thus characteristically nova-like. An outline of the increase of this nova is given in POPULAR ASTRONOMY, **47**, 336, 1939. About sixty days were required for the rise through three magnitudes to the point where the increase quickly slackened.

The complete course of variation of these stars is as yet unknown, nor is it possible to state their typical range. That of DO Aquilae was greater than 7.9 magnitudes, and that of Wachmann's star (Nova Orionis 1939) appears to be about six magnitudes.

IRREGULAR CURVES

The most ambiguous object in this category is Anthelm's Nova Vulpeculae of 1670. First seen as a third magnitude object, it dropped below sixth magnitude in four months. But five months after its disappearance it was again visible. Two maxima at the third magnitude followed in the next two months; then it declined and passed from naked-eye visibility about fourteen months after its discovery.

Another example of a very bright second maximum after a long decline is furnished by Nova Ophiuchi 1917. The brightest recorded mag-

nitude was 6.3. In three months it declined nearly to twelfth magnitude, then brightened suddenly to 8.2 and declined again to twelfth magnitude in two months. The form of the curve does not permit the interpretation of this second maximum as a recovery following the "transition." Possibly we should relegate this star to the nova-like objects, among which Z Andromedae furnishes a partial parallel.

The star called Nova Aquilae No. 4 (1919) was so erratic in its behavior that it is probably to be barred from the class of novae. Lundmark suggested a bright maximum of light during a long unobserved interval, but even with this interpretation the star is abnormal. Ludendorff, on the other hand, considered it as an R Coronae variable. Its spectral class, R0, is favorable to that view.

Nova Ophiuchi 1919 had a second maximum of light equal to the principal maximum, though this is only a slight abnormality, since several novae have shown second maxima less than a magnitude fainter than the principal one. Incidentally, the second maximum is incorrectly placed on the curve reproduced in *Publ. A. S. P.*, **33**, 190, 1921. It is shown there about one month after principal maximum; actually the interval was two months.

A slight deviation from typical behavior was shown by Nova Geminorum 1903. On the decline, at about 3.5 magnitudes below maximum, it had a "stillstand" for about three weeks, and then quickly faded until its magnitude reached the smooth continuation of the earlier decline.

Repeating Novae

Three objects can be definitely assigned to this class:

RS Ophiuchi, with maxima in 1898 and 1933,
T Pyxidis, with maxima in 1890, 1902, and 1920,
Nova Sagittarii 1919, with a smaller (?) increase in 1901.

The first two are very well known; the third appears to have received scant attention. It is not known to the writer whether the maximum of 1901 was widely missed (in which case it might have been equal to that of 1919) or was actually faint, since the detailed observations have never been published.

The evidence concerning the supposed repeating nova in Orion (1667, 1750, and 1894) is not entirely convincing, and it should not be placed on a list of authentic repeating novae.

Another object which will bear watching is T Coronae, which was a nova in 1866 and showed small fluctuations for many years afterward. Particular suspicion attaches to it because it showed a definite increase of brightness with spectral changes in 1938. The fact that bright lines which are abnormal for a class M star were visible in the spectrum some years earlier would appear to indicate that the nova is certainly not more than a couple of magnitudes fainter than its class M companion. This star has been suspected of repetition, but it is probable that the earlier

observation (1842) actually referred to a seventh magnitude star a degree away.[6]

[6] McLaughlin, POPULAR ASTRONOMY, **47**, 353, 1939.

(To be continued)

Planet Notes for December, 1939

By R. S. ZUG

NOTE: Greenwich Civil Time is employed unless otherwise stated. To obtain Eastern Standard Time subtract 5 hours, Central Standard Time, 6 hours, etc. The planetary phenomena are described as they are to be seen from latitude 45° N. The data are taken chiefly from the *American Ephemeris and Nautical Almanac*.

Sun. The apparent positions of the sun for December 1 and December 31, respectively, are: $\alpha = 16^h\,24^m.4$, $\delta = -21°\,37'.7$; $\alpha = 18^h\,36^m.6$, $\delta = -23°\,10'.7$. The sun is in the constellation Ophiuchus until December 18, when it enters Sagittarius. It is in Sagittarius for the remainder of the month. The sun reaches the winter solstice December 22 at $18^h\,6^m$, at which instant the season of winter begins. Values for the equation of time are as follows:

Date 1939	Equation of Time (Mean - Apparent) m s	Date 1939	Equation of Time (Mean - Apparent) m s
Dec. 1	−11 22	Dec. 17	− 4 25
5	− 9 50	21	− 2 27
9	− 8 9	25	− 0 28
13	− 6 20	29	+ 1 31

Moon. Phenomena of the moon will occur as follows:

		h	m
Last Quarter	Dec. 3	20	40
New Moon	10	21	45
First Quarter	18	21	4
Full Moon	26	11	28
Perigee	Dec. 3	7	
Apogee	17	16	
Perigee	29	11	

Mercury. Mercury will be a morning star during December. It will attain a maximum elongation from the sun of 21° 25′ on December 17, and on that day will be of stellar magnitude −0.2. The southerly declination (−23°) of the planet will render it an inconspicuous morning star for observers in the northern hemisphere. An occultation of Mercury is predicted for December 9, 9^h.

Venus. Venus is now to be seen as an evening star, low in the southwestern sky after sunset. The planet will set about an hour after the sun on December 1, but by December 31 it will remain in view for two hours after sunset. The magnitude of the planet during December is −3.3.

Mars. Mars is still an evening star, in Capricornus. In brightness, the planet varies from stellar magnitude +0.2 on December 1 to +0.7 on December 31.

Jupiter. Jupiter is well located for evening observation during December. The planet will be in quadrature with the sun on December 18. On December 13

Jupiter will be located on the equinoxial colure, 1° 30′ south of the vernal equinox. The stellar magnitude of the planet during December will be about —2.0.

Saturn. Saturn is situated 7° north of the celestial equator in the eastern part of the constellation Pisces. The stellar magnitude of the planet is +0.5 during December. The angular dimensions of the major and minor axes of the rings are 43″ and 10″, respectively, during December. The southern side of the ring system is now visible from the earth.

Uranus. Uranus is a morning object, about two hours west of the sun. Apparent positions of the planet for December 1 and December 31, respectively, are: $\alpha = 3^h\ 7^m.5$, $\delta = +17°\ 13'.5$; $\alpha = 3^h\ 3^m.7$, $\delta = +16°\ 58'.4$.

Neptune. Neptune is in the morning sky during December, and on December 1 and December 31, respectively, will be situated in right ascension and declination as follows: $\alpha = 11^h\ 44^m.6$, $\delta = +2°\ 57'.4$; $\alpha = 11^h\ 45^m.5$, $\delta = +2°\ 53'.6$.

Occultation Predictions

(Taken from the *American Ephemeris*)

Date 1939		Star	Mag.	IMMERSION Greenwich C.T. h m	IMMERSION a m	IMMERSION b m	IMMERSION Angle E from N °	EMERSION Greenwich C.T. h m	EMERSION a m	EMERSION b m	EMERSION Angle E from N °
Occultations Visible in Longitude +72° 30′, Latitude +42° 30′.											
Dec.	2	*o* Leo	5.5	10 17.6	—0.8	—2.9	159	11 12.3	—2.2	+0.1	250
	6	*g* Vir	5.7	11 29.7	—1.6	0.0	112	12 47.3	—1.6	—0.7	300
	18	21 Psc	5.8	23 32.9	—2.0	+0.2	75	0 57.1	—1.4	+0.6	230
	24	162 B.Tau	6.3	1 10.5	—1.8	+1.0	83	2 32.5	—1.8	+0.8	251
	24	180 B.Tau	6.1	5 56.7	—0.8	—3.6	140	6 39.8	—1.4	+1.3	214
	25	*m* Tau	5.0	6 40.4	—1.3	—0.6	77	7 46.6	—0.6	—1.9	289
	28	BD+14°1850	6.4	9 37.4	—0.5	—2.4	144	10 30.9	—1.0	—0.9	254
	29	60 Cnc	5.7	1 28.3	—0.4	—0.7	149	2 7.3	—0.1	+2.6	234
	29	*a* Cnc	4.3	2 23.9	—0.3	+2.2	68	3 14.4	—0.8	—0.5	318
	29	*κ* Cnc	5.1	8 9.6	..	..	182	8 36.4	..	..	223
Occultations Visible in Longitude +91° 0′, Latitude +40° 0′.											
Dec.	1	84 B.Cnc	6.4	10 33.9	..	..	40	10 59.3	..	..	3
	6	*g* Vir	5.7	11 10.2	—0.7	—0.7	142	12 15.0	—1.7	+0.8	269
	18	21 Psc	5.8	22 54.8	—1.7	+1.7	55	0 24.5	—2.0	+0.8	246
	24	162 B.Tau	6.3	0 41.8	—1.0	+1.8	71	1 56.7	—1.5	+1.2	259
	25	*m* Tau	5.0	6 12.4	—1.8	—0.7	95	7 31.0	—1.5	—0.9	267
	28	30 B.Cnc	6.1	8 8.0	—2.4	+1.1	65	9 3.8	—0.9	—3.1	333
	29	*a* Cnc	4.3	2 18.5	+0.2	+1.9	66	3 3.5	—0.4	—0.2	316
Occultations Visible in Longitude +120° 0′, Latitude +36° 0′.											
Dec.	1	84 B.Cnc	6.4	9 18.8	—1.7	+1.0	88	10 34.2	—1.8	—0.9	304
	4	359 BlLeo	6.3	11 50.8	—1.5	+0.5	103	13 4.6	—1.4	—1.0	312
	24	162 B.Tau	6.3	0 23.2	+0.2	+2.1	49	1 17.4	—0.7	+0.8	282
	25	*m* Tau	5.0	5 12.8	—2.1	+0.1	102	6 33.3	—2.1	+1.2	246
	28	30 B.Cnc	6.1	7 6.7	—1.6	+0.7	96	8 23.7	—1.8	—0.3	290
	31	p^4 Leo	5.7	10 1.3	—2.3	+2.6	66	10 48.5	—0.7	—3.0	348

The quantities in the columns *a* and *b* are given for the purpose of making these predictions useful for any place within 200 miles of the point indicated. The procedure is as follows: Subtract the longitude of the point given from the longitude of the place in question; multiply the result in degrees, taking the signs into account, by the quantity under *a* for the star to be observed; similarly,

with the latitude, using b; apply the sum of the products, with its proper sign, to the Greenwich C.T., and obtain the predicted Greenwich Civil Time for the phenomenon at the place of observation. To obtain Eastern Standard Time it is necessary to subtract five hours; Central Standard Time, six hours, etc.

METEORS AND METEORITES

Meteor Notes from the American Meteor Society

By CHARLES P. OLIVIER, President

In these "Notes" the résumé of the reports so far received for the past summer is given. It is certain that some of our Sections did work not as yet in my hands; this as usual will have to appear later. Apparently the newspaper publicity was poorer this year than usual, for the number of casual observers was small. However, on the favorable side, a larger proportion of the observers plotted the meteors seen and the tabular results are very full and complete in many cases, the instructions having been carefully followed. Also we welcome several groups which reported for the first time, for instance that at Des Moines, Iowa, at Wheeling, West Virginia, and that at Tulsa, Oklahoma. Experience shows that when a group becomes really interested better results from each member may be expected. The data are divided into two tables, Table I containing reports of individuals or groups, all or some of which plotted the meteors seen and in general kept full records. Table II contains data from others who made counts only or, if plotting, did not send in the plots or the full details. This is the group which is smaller, due to the poorer newspaper publicity in 1939. The night of August 11 furnished a brilliant aurora which for a time, in many places, was so brilliant that observations were curtailed or completely stopped. It seems to have been seen over most of the country, certainly as far south as Kentucky.

The outstanding single report is that of E. Loreta who, taking full advantage of the clear Italian skies, was able to work on many successive nights. He also sends drawings of several long-enduring, drifting trains, which he followed with binoculars after they became invisible to the naked eye. This is a thing I have urged other A.M.S. members to do, noting his remarkable success. A glance at the tables shows that for America the hourly rates at maximum were not very different from the average year when the moon is absent. Loreta, however, remarks: "Maximum of the Perseids night of August 12-13, followed in order by 11-12, 13-14, and 10-11. Maximum feeble this year, a little more feeble than in 1936 and a little less feeble than in 1937." His data give: mean magn. of Perseids 2.95; of sporadic meteors 3.37. These values are based on 255 Perseids and 265 sporadic. He notes that 47% of Perseids left trains but only 8% of sporadic, a truly remarkable difference. I regret to say that, so far as I know, Loreta has never received proper recognition in Italy for his excellent work, nor the encouragement there which he deserves. However, he is highly appreciated elsewhere and I hope that his native land will accord him more recognition when it is realized what his reputation is abroad.

While I fully realize that few men, due to their professions, are able to put the time and effort on observing that Loreta does, still there are some. Such persons could become the great observers in their chosen branch. There must be men

and women in America who have both the love of science and the necessary leisure. It would be to the mutual benefit of everyone if I could find a few such persons for the A.M.S.

The rates given in the tables are uncorrected. To obtain corrected rates divide by factor F. It should be noted that it takes the average observer fully one minute to properly plot and record a meteor. Hence, the rates in Table I, for those who plotted, would have to be increased largely to make them comparable with those of persons who counted only. While the correction may readily be obtained by formula, for most of these persons, who have indeed not plotted very frequently, when as many as 15 or more meteors were plotted per hour, we might double their rate, as a first approximation, to make it comparable with the rates of those counting only. It is not possible to work out comparable rates for groups, as our unit is what *one person sees in one hour.* Dividing a combined rate by the number of observers does not give this at all. Hence rates for more than one observer are left blank. I have not been able as yet to work up the radiants which apparently will be found on very many maps. These will be published later after proper study. Again all our members are urged to write for needed maps and blanks well in advance so that delays in transit, etc., will do no particular harm. Full supplies of both are now available here and orders can be at once filled.

Station and Observer	Date 1939	Began	Ended	Min.	Met.	F.	Unc.R.	*
Sheffield, Ala., G. Heaton..... June	19	13:00	15:30	150	20	1.0	8	
	21	12:45	15:30	165	19	0.9	7	
Aug.	9	12:00	14:30	150	26	0.9	10	
	10	13:20	15:30	130	31	0.9	14	
	11	13:00	16:20	200	46	0.9	14	
Long Island,N.Y.,Mrs.G.C.Rademacher	10	11:00	14:00	180	38	1.0	13	
Miss B. Shortmeurig	10	11:00	14:00	180	50	1.0	17	(1)
Dr. Rademacher	10	9:30	12:30	180	26	1.0	9	(1)
Mrs. G. C. Rademacher	11	11:30	12:30	60	10	0.3	10	(2)
Miss B. Shortmeurig	11	11:30	12:30	60	27	0.3	27	(3)
N.W. Corner, Ill., P. N. Klass... June	3	9:00	10:00	60	6	0.9	6	
	4	8:30	9:30	60	11	1.0	11	
	20	11:45	12:45	60	9	1.0	9	
July	5	9:00	10:00	60	10	0.9	10	
	7	8:45	10:15	90	14	0.9	10	
	8	8:45	10:30	105	10	1.0	6	
Aug.	3	8:30	9:30	60	10	1.0	10	
	8	10:30	11:30	60	10	1.0	10	
	12	8:30	10:00	90	36	1.0	24	
	20	14:15	15:45	90	15	1.0	10	
	21	14:30	15:00	30	10	1.0	20	
Chicago, Ill., W. R. Morris .....Aug.	10	10:45	11:45	60	3	0.5	3	
	12	10:05	12:35	150	12	0.7	5	
	13	11:15	12:45	90	13	1.0	9	
Booneville, Iowa, F. R. Vaughn..Aug.	11	9:30	10:30	60	19	0.6	19	(2)
A. E. Chenwell	11	10:55	11:55	60	21	0.4	21	(2)
G. Dunevent	11	11:02	12:02	60	20	0.3	20	(2)
Camp Dodge, Iowa, K. Tusant ...	12	12:20	16:05	180	91	1.0	30	
P. R. Engle	12	10:48	11:48	60	26	1.0	26	
Des Moines, Iowa, W. H. Hass ...	12	12:06	14:13	120	46	1.0	23	
		14:30	15:30	60	57	1.0	57	(1)
F. R. Vaughn	12	14:26	16:02	90	86	1.0	57	
H. M. Johnson	12	11:07	15:50	..	34	0.9	..	
Augusta, Kansas, J. Justice	11	11:	:	..	25	..	..	
Kingman, Kansas, N. H. Hull	11	10:30	11:15	45	8	..	..	(2)

Station and Observer	Date 1939	Began	Ended	Min.	Met.	F.	Unc.	R.	*
Louisville, Ky., Miss M. Shapinski	10	10:00	12:00	120	38	1.0	19		
A. Harding	10	10:00	12:00	120	32	1.0	16		(1)
M. Ulrich	10	10:00	12:00	120	33	1.0	16		(1)
C. Jansing	11	8:50	10:30	100	17	0.7	10		(3)
M. Eberhard	11	8:50	10:30	100	15	0.7	9		(3)
W. L. Moore	11	8:50	11:30	160	30	0.7	11		(2)
Otter Creek, Ky., A. Harding	11	10:00	12:00	90	18	0.5	12		(3)
E. Johnson	11	10:00	12:00	90	11	0.5	7		(3)
C. Rader	11	10:00	12:00	90	18	0.5	12		(3)
M. Ulrich	11	10:00	12:00	90	18	0.5	12		(3)
J. E. Ulrich	11	10:00	12:00	90	18	0.5	12		(3)
Miss M. Shapinski	11	10:	12:	..	8	0.5	..		(2)
Portland, Maine, R. M. Dole	10	12:00	14:00	120	60	1.0	30		
	12	13:30	14:15	45	34	0.6	45		
	15	14:45	15:45	60	9	..	9		
N. Quincy, Mass., C. McArthur	11	14:05	15:32	..	30	0.5	..		(2)
Hibbing, Minn., R. J. Mastell ....July	27	11:00	13:23	143	12	1.0	5		
Aug.	12	10:00	12:33	153	22	0.4	9		
	16	12:00	13:59	119	17	1.0	9		
	18	11:14	12:00	46	6	1.0	8		
Blue Earth, Minn., G. Pirsig ....Aug.	9	11:20	12:00	30	8	1.0	16		
Springfield, Mo., J. L. Sullens	10	10:30	12:45	135	21	1.0	9		
	12	11:30	14:30	180	162	1.0	..		(4)
Banks, N. D., V. Arery	11	10:40	15:00	145	23	0.5	10		(2)
	12	9:44	13:07	203	48	1.0	14		
	13	9:26	11:31	125	22	1.0	11		
Newburgh, N. Y., C. D. Robinson..	10	10:55	11:55	60	8	1.0	8		
Bronx, N. Y., M. Lambert	6	13:55	:	60+	9	0.8	9		
	9	12:00	13:00	60	9	1.0	9		
G. E. Lambert	10	12:11	13:21	70+	14	1.0	12		
	11	11:58	12:58	60	14	0.5	14		(2)
	13	13:05	15:33	148	23	0.8	9		
	14	10:55	12:28	93	7	..	5		
	15	10:34	12:10	96	3	0.4	2		
	22	11:00	12:23	83	4	0.6	3		
	23	10:30	12:15	105	3	0.6	2		
Fremont, Ohio, C. T. Hardy .....July	30	10:30	12:30	120	4	0.4	2		
	31	10:00	12:30	150	9	0.4	4		
Aug.	10	10:40	15:30	290	115	0.9	24		
Yucker	10	10:40	15:30	290	105	0.9	22		
Hardy	11	9:10	11:40	150	16	0.4	6		(2)
Yucker	11	9:10	11:30	140	19	0.4	8		(2)
Hardy	13	10:45	16:15	330	185	0.9	34		
E. Cleveland, Ohio, W. Wallace..July	11	11:15	13:15	120	9	1.0	4		
	14	13:30	14:00	150	8	1.0	3		
	16	11:15	13:15	120	6	1.0	3		
	21	11:15	14:00	165	10	1.0	4		
Aug.	10	11:30	14:00	150	17	1.0	7		
	13	12:00	15:00	180	64	1.0	21		
Nashville, Tenn., C. E. Huckaba..	10	14:11	15:17	66+	12	..	..		
	11	12:41	15:19	158+	41	..	..		
	14	11:05	11:44	39+	8	..	12		
Ooltewah, Tenn., P. O. Parker	10	10:55	14:05	130	21	0.8	..		
Begumpet, India, M. A. R. Khan June	14	21:45	22:45	60	5	0.7	5		(5)
	18	21:10	21:55	45	8	0.9	11		
	19	18:30	23:15	90	11	0.8	7		
	25	22:00	22:45	45	7	0.7	9		
July	15	20:45	21:30	45	9	0.5	12		
	24	20:30	21:30	60	21	0.8	21		

Station and Observer	Date 1939	Began	Ended	Min.	Met.	F.	Unc.	R.	*
	25	21:00	21:30	30	9	0.5		18	
	Aug. 5	23:00	23:30	30	7	0.6		14	
	6	20:15	21:00	45	4	0.5		5	
	7	20:45	12:30	45	4	0.6		5	
	8	20:30	21:30	60	7	0.5		7	
Bologna, Italy, E. Loreta .....July	13	9:00	9:55	50	4	..		5	(6)
	14	9:00	9:55	50	7	..		8	
	15	9:00	9:55	50	4	..		5	
	16	9:00	9:55	50	5	..		6	
	17	9:00	9:55	50	4	..		5	
	19	9:00	9:55	50	5	..		6	
	25	13:00	13:55	50	20	..		24	
	26	13:00	13:55	50	10	..		12	
	Aug. 8	8:30	10:25	100	13	..		8	
	9	8:30	11:25	100	43	..		26	
	10	8:30	14:25	225	99	..		26	
	11	12:30	13:55	75	50	..		40	
	12	8:30	13:55	200	135	..		40	
	13	8:30	12:55	100	33	..		20	
	14	8:30	11:25	75	23	..		18	
	15	8:30	9:25	50	14	..		17	
	16	8:30	9:25	50	11	..		13	
	17	9:00	9:55	50	6	..		7	
	18	9:00	10:25	75	16	..		13	
	19	8:30	9:25	50	15	..		18	
Pomona, Calif., Miss M. Jones ..Aug.	12	13:30	15:35	120	68	0.9		34	
Kaunakakai, H. T., F. A. Palmer..	10	13:20	13:35	15	..	..		..	(7)
Topeka, Kan., E. M. Wiedermann.	12	10:	12:	..	5	..		..	
	13	:	:	..	5	..		..	
Springfield, Mo., Mrs. W. R. Coffing	10	11:	12:	60	16	..		..	(8)
Bayonne, N. H., J. Habereck	12	11:28	15:23	..	24	0.9		..	
Inwood Park, N. Y., Jr. Astr. Club	11	11:00	14:31	211	43	0.4		..	(9)
Ridgefield, Conn., Jr. Astr. Club ..	11	12:00	12:30	30	18	..		..	
	12	9:09	13:40	214	93	0.7		..	(9)
Tulsa, Okla., L. Desjardins	12	12:30	15:00	75	250	..		..	(10)
Eugene, Ore., Mrs. F. Thomson...	12	13:15	14:15	27	60	0.9		27	
Miss B. J. Thomson	12	13:15	14:15	31	60	0.9		31	
F. Wood	12	13:15	14:15	36	60	0.9		36	
J. H. Pruett	12	13:15	15:15	91	120	0.9		46	
Pittsburgh, Pa., N. Waithus	11	13:	17:16	..	10	..		..	
Philadelphia, Pa., R. Gorson	13	12:13	14:20	120	24	0.3		12	
Pawtucket, R. I., D. Partridge	11	11:00	15:00	240	172	..		43	
Appleton, Wis., Mrs. A. Furtmann.	12	10:	11:	60	31	..		31	(11)
	13	10:	11:	60	40	..		40	
	15	9:	10:	60	30	..		30	
Wheeling, W. Va., L. Metz	11	9:	13:	240	125	0.4		..	(12)
	11	13:	16:15	195	201	0.9		..	(12)

NOTES: (1) count. (2) aurora. (3) count, aurora. (4) 2 observers. (5) Times U.T. (6) Times I. A. Gr. (7) "many brilliant." (8) 3 obs. (9) ? observers. (10) 12 observers; 121 charted meteors. (11) aurora Aug. 11. (12) 4 observers; aurora.

Flower Observatory, Upper Darby, Pennsylvania, 1939 October 10.

Contributions of the Society for Research on Meteorites

Edited by FREDERICK C. LEONARD,
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The Washougal, Washington, Aërolite

By J. HUGH PRUETT,
General Extension Division, University of Oregon, Eugene

ABSTRACT

This paper contains a detailed account of the finding, identification, *etc.*, of the meteorite discovered by Mr. Jerry E. Best on his farm about a mile north of the town of Washougal, Clark County, Washington, on July 3, 1939, the day after the audible Portland, Oregon, meteor appeared. The meteorite, which is about as large as a tennis ball, is covered by a thin, black, glazed crust and is an aërolite of the comparatively rare Howardite variety. This is the first meteorite on record for the State of Washington.

Following is a complete account of the finding of the aërolite discovered near Washougal, Clark County, Washington, on July 3, 1939, the day after the noisy Portland, Oregon, meteor appeared.

During the past several years, I have been receiving an abundance of rock specimens from residents of the Pacific Coast, especially the Pacific Northwest, who believe that they have found actual meteorites. We examine the specimens here with the able assistance of Dr. Warren D. Smith, the head of the Department of Geology of the University of Oregon. Anything that is not readily recognized to be terrestrial, is forwarded to the American Meteorite Laboratory of Dr. H. H. Nininger in Denver, Colorado. Up to the present month (August, 1939), not one of the hundreds of specimens that have been received has proved to be a meteorite!

On August 18, 1939, another sample arrived in my mail box at Deady Hall, University of Oregon. Mr. Don Hunter, University technician (a member of the Society for Research on Meteorites), saw me taking the package from the mail box and remarked humorously, "I see you have received another meteorite!" I shared his skepticism. After discussing other matters, I opened the package. Then our eyes, also, opened! Out of the box came a black object, about the size of a tennis ball. A few broken places on the crust revealed a very light gray interior. It struck us at once that the body was something entirely different from the ordinary specimens received. We felt that there were excellent chances that this was a real meteorite. Tests were made with various paint-removing chemicals to see whether the crust could have been put on artificially. The chemicals had absolutely no effect. I left the specimen with Mr. Hunter for an hour until I returned from town. He had found by the time I returned that the specimen as a whole was mildly magnetic and that bits from it were readily attracted to a small magnet. The conglomerate internal structure contained numerous greenish-yellow crystals which, we remarked, looked almost exactly like olivine. We noted also the corrugated

effect on the crust, which is characteristic of many meteorites. Fire was applied to a small part of the crust which had been removed from the surface. Not the least alteration took place. That night Mr. Hunter made another examination of the specimen at my home. We were convinced that the object was a meteorite and that it should be sent to Dr. Nininger for final verification. The next morning the specimen was taken to Dr. Smith, the University geologist, for a final local inspection. After examining it carefully with his strong hand-lens, he remarked, "If that is *not* a meteorite, it is certainly a good *imitation* of one! By all means send it to Dr. Nininger at once!" It was mailed a few minutes later.

Accompanying the specimen when it arrived in Eugene was a letter from Mr. Jerry E. Best, Route No. 2, Washougal, Washington. This read as follows:

"Under separate cover I am inclosing what I believe to be a piece of the meteor[ite] that passed over here on July 2nd. I would have sent it in much sooner, except that I did not know your address, but, thanks to your article in *The Oregonian*, it gave me a definite address and the [name of the] person to whom this might have some significance, provided, of course, that it *is* a piece of the meteor[ite]!

"One thing puzzles me. According to the map, the meteor was traveling from west to east. According to the sound of the 'explosion' that was heard so prominently in Portland, from [the place] where I heard it, the direction of travel was [apparently] the exact opposite. [It was learned later that Mr. Best was at his farm home near Washougal. His reference to Portland does not mean that he was there.—J.H.P.] Could this [effect] have been caused by the slower speed of sound? Anyway, I realized almost at once what it [the phenomenon] was, and tried to judge by hills and trees its approximate position. Returning to the house for a compass and protractor, I managed to get an angle of about 45° in the direction of Portland, to about 75° here. I don't know the compass deviation for this locality; so, pointing the needle due north, I got a reading of about 240° to 270° for the 'length' of the noise.

"Next morning, after listening to the radio reports, I went back to check up again. Cutting up over the ridge through a small grove in back of the house, I found the piece of meteor[ite](?). The broken spots on the outer covering were caused by myself and some friends to see what it was. It couldn't have had much speed when it landed, because of the condition of the duff under the trees. Even right after picking it up, it was hard to tell where it had been lying. I even climbed most of the trees around the spot to see whether there were any broken twigs in the upper branches. The location of the find, if it is a find, is 500 yards W., 100 yards S. of the N.E. corner of Sec. 8, T. 1 N., R. 4 E.

"You are welcome to the object if it is of any value to you, Mr. Pruett, and you can satisfy my curiosity if you will be so kind as to let me know what it is. One lady I know contends that it is a piece of concrete dipped in tar! . . ."

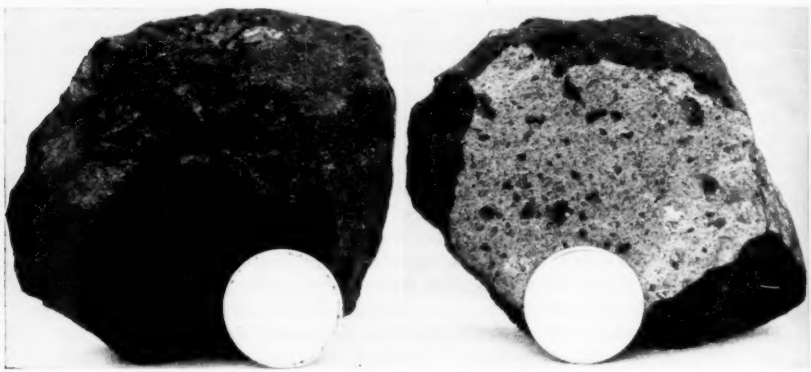
On the morning of August 23, a Western-Union telegram was received from Dr. Nininger. It read as follows:

"Specimen genuine meteorite. No doubt many specimens been picked up in vicinity. If can know who found it, will have trained student who lives in Portland conduct search at once. Wire Western Union. Letter follows."

Immediately after its receipt, this information was relayed to Mr. Hunter who, certain that the object was a meteorite at the time when it was first examined here, planned to make a search in the locality of Washougal in the week-end of August 26-27. Upon verification of his idea, he arranged with the University to obtain

time off, at once. With a photographer friend, he drove to Portland the evening of the day the telegram was received and on to Washougal the next day. While in Portland, he interviewed a woman who had reported that a rock, alleged to be a meteorite, was being displayed at a store in Washington, at a place across the river from The Dalles, Oregon. From Portland, Mr. Hunter crossed the river to Vancouver, Washington, and twice, in the course of the day, called at the Best home about one mile north of Washougal. Mr. Best very kindly went over the entire incident with him. At the time of the flight of the meteor, Mr. Best was picking berries in his farm patch, which was only a few hundred yards north of his house. The find was made on a ridge, which was between the house and the berry patch. The meteorite had thus passed over him! He did not hear the characteristic whistling sound of meteorites falling nearby, but said that the detonations in the heavens kept him so busy that he would have overlooked any minor disturbances.

Mr. Hunter examined the ground where the meteorite was found. He reports that the hard surface had a distinct dent in it, about one or 1½ inches in depth. This was hardly noticeable when one looked at the fir needles covering the dent, but it was very noticeable when the hand was placed on top of the needle covering. Excellent photographs were obtained of the location and Mr. Best.



TWO VIEWS OF THE WASHOUGAL, WASHINGTON, AËROLITE, one showing the black fusion crust entire, the other, the cut face and the interior of the stone, which contains numerous yellowish-green crystals of olivine. The weight of the meteorite when found was approximately 220 g. The white disk in the foreground is of the size of a dime. (Natural size.)

The Washougal aërolite is the first meteorite ever found and identified as such in the State of Washington. This is practically the only State which, up to the present time, has had no meteorite discovery to its credit. A few years ago, *The Spokane Press* had a standing offer of a prize of $5 to the person who would find, and have identified, a true meteorite in the State of Washington, and thus take the State out of the "have-not" class. Mr. Best has been informed that he is eligible to claim this prize! However, last spring, *The Spokane Press* had financial diffi-

culties and discontinued publication. No other paper has agreed to carry on the offer!

At the store across the river from The Dalles (probably at Grand Dalles, but I am not certain), Mr. Hunter found the aforementioned rock (the alleged meteorite) on display. It was said that this had been found in a hay field shortly after the meteoric disturbance of July 2. Mr. Hunter carefully examined the rock and reports that it has no resemblance to the Washougal meteorite and that he is sure that it is not meteoritic.

It is proposed that Mr. Best's find be named the Washougal, Clark County, Washington, meteorite. Washougal is on the north bank of the Columbia River, in Washington, while Portland is in Oregon. Portland is only fifteen or twenty miles from Washougal, but it seems hardly proper to give a Washington find the name of an Oregon city.*

Mr. Hunter is of the opinion that he has examined almost every black rock lying along the stretch of road from Vancouver, Washington, to the point across the river from The Dalles, Oregon, nearly one hundred miles east! He reports that he never knew before that so many black rocks existed along the road side! His trip yielded only negative results, however, in so far as the finding of any more meteorites is concerned.

Part of Dr. Nininger's letter which followed the telegram previously quoted, is as follows:

"You have doubtless received my wire by this time. The specimen which you sent is a genuine meteorite and a very fine one. This meteorite appears to belong to the group of Howardites, which are usually very friable and therefore largely destroyed by the aërial conflict. What remains, falls usually in the form of small fragments nicely glazed over with the black crust. . . . If the published maps of your survey have been correctly reproduced, then we have here a case where the showering took place probably several miles back of the end point of the meteor, just as was the case with the Pasamonte, New Mexico, fall, which belongs to the same friable group of meteorites."

The seven persons in Eugene who are members of the American Meteor Society or the Society for Research on Meteorites, have considered at some length the desirability of releasing the news of this find to the public. It is the unanimous decision of the seven that, since the press and the public were called upon to assist in tracing the meteor, and since all coöperated so generously and have shown such an interest in the meteor and later in what they thought were meteorites, it is only just that the public, whose confidence here in the Pacific Northwest we are so desirous of keeping, should at once be informed of the find and given an opportunity to share in the discovery of any additional fragments of this interesting meteorite. It is hoped also that trained students of meteorites will assist in the search for more specimens of the fall.

*[The appropriate name for this aërolite is, in the circumstances, undoubtedly Washougal, Washington.—EDITOR.]

Note on the Washougal, Washington, Aërolite

By H. H. NININGER

I have just received (August 22, 1939) for verification, from Professor J. Hugh Pruett of the University of Oregon, Eugene, a beautiful little aërolite, which, according to him, was picked up near Washougal, Washington, a short distance east of Portland, Oregon, on the morning after the great meteoric display of July 2,

1939. The meteorite appears to belong to the group of Howardites, closely resembling the fall of March 24, 1933, at Pasamonte, New Mexico, and that of August 8, 1933, in Sioux County, Nebraska. It is an almost complete individual of irregular form, incased in a beautiful, glossy-black covering of glass which is very thin. Its form indicates a thorough breaking up of the parent mass, this specimen appearing to have been released too late for the irregularities of its surface to be erased.

The interior of the specimen consists mainly of finely-divided, light-gray material, resembling volcanic ash. Imbedded in this are crystalline fragments of olivine and probably other minerals, as yet unidentified. A few small, rusty spots suggest the presence of metallic iron, but a test for nickel gave negative results.

This fall adds further weight to the suggestion made by me (*Jour. Geol.*, **46**, 890, last par., 1938), that probably Howardites and other less easily recognized varieties of meteorites are not so rare as has been generally supposed. The Howardite type of meteorite is of infrequent occurrence in collections, doubtless *because* it is not usually recognized.

Diamonds in Canyon Diablo, Arizona, Meteorites

By H. H. NININGER

ABSTRACT

The method of detection, appearance, hardness, *etc.*, of carbonadoes (so-called "black diamonds"), in Canyon Diablo, Arizona, meteorites, are described. In the past nine years, carbonadoes have been encountered in about twenty specimens. These carbonadoes were usually imbedded in nodules or veins of dark sulfide and carbonaceous material, though in some instances they occurred in schreibersite inclusions; in one case, they were associated with a small cavity which occupied the central part of a schreibersite inclusion. The occurrence of diamonds near a cavity lends apparently no support to the common belief that their presence in meteorites constitutes conclusive evidence of cooling under high pressure.

In our Laboratory, meteorite specimens are ground and polished, not upon a wet lap, as is commonly done, but upon a revolving, dry carborundum disk. This method has certain advantages for the student of meteorites, for the reason that the specimen is at all times in a suitable condition for a critical examination of the manner in which it reacts to the process. A specific instance of how this manner of treatment sometimes proves advantageous was our discovery several years ago of one of the carbonadoes, or so-called "black diamonds," for which the Canyon Diablo, Arizona, meteorites became noted in the last decade of the nineteenth century. On this particular occasion, we were preparing a number of small slices of the Canyon Diablo irons for cabinet use and had run the lot over the first two disks. We were then working on the third disk, which carried No. 240 grit. Everything proceeded as usual until we came to the last specimen of the lot, which had shown a bad tendency to become scratched in certain areas. Small, fan-shaped groups of scratches had persisted in appearing. These seemed to spread out to the "leeward" of certain minute points and no amount of grinding would eliminate them. We had not taken the matter very seriously during the grinding on disks Nos. 1 and 2 and had not examined the areas under a lens; but when the specimen was applied to disk No. 3, something happened which at once arrested our critical attention. A white streak appeared on the disk, in the wake of a certain point on the specimen. We watched this streak interestedly, as it marked the face of the

disk like an unwinding thread, round and round, in graceful spirals, as we moved the specimen about on the disk. Soon it became evident that these spirals were not mere marks, for the carborundum cloth began to fall apart. We stopped the machine and saw that the disk was being cut into shreds! A survey of the face of the specimen revealed a small, black, protruding knot, barely visible to the unaided eye, from which stretched away, like the tail of a comet, a band of scratches reaching to the edge of the specimen. I knew of the diamonds reported in Canyon Diablo meteorites by Foote, Koenig, Huntington, Kunz, and others. At once I suspected that we had found one.

FIGURE 1

A SECTION OF A CANYON DIABLO METEORITE, showing a schreibersite nodule in which carbonadoes were found. (About ⅔ natural size.)

Another lot of irons was cut, and several other similar objects were encountered. A year later, while a pair of book ends were being prepared from one of these irons, a lump about 2 mm. in length was encountered. This was sufficient to turn the course of the saw during cutting and was readily discovered without waiting for the grinding to reveal it. Still later, in almost the center of a 4-pound iron, a cavity was exposed which was bounded by a zone of carbonaceous-looking material, about half of which seemed to be composed of the resistant substance which was so destructive to carborundum. The cavity was about 7×2 mm., and the bordering zone had an average width of about 1 mm. A microscopic examination of the resistant lumps showed them to consist of a blackish substance, which in appearance resembled graphite, but which, under a magnification of $\times 100$, was found to be impregnated with numerous white, bluish-white, and yellowish-white, transparent crystals, which in many instances were seen to be standing out prominently above the general surface of the dark material. These were the cutting agents

which had been guilty of carving our carborundum disks into shreds and which, when too deeply undercut, had been loosed and dragged across the face of the specimen, scratching it as they went. It was evident that we were dealing here with carbonadoes. In the course of our work of the past nine years, we have encountered carbonadoes in about twenty specimens. They are usually imbedded in nodules or veins of dark sulfide and carbonaceous material, though in some instances they have been found in schreibersite inclusions.

FIGURE 2

A SCHREIBERSITE NODULE,
with cavity in center, surrounded by a carbonaceous zone
in which carbonadoes are located, as shown on the
accompanying map (Fig. 3).

It has been mentioned that, in one instance, the carbonadoes were found associated with a small cavity. This cavity occupied the central part of a schreibersite inclusion. The occurrence of the diamonds bordering a cavity does not seem to lend strength to the common belief that their presence in meteorites constitutes conclusive evidence of cooling under high pressure.

Some of these carbonadoes were applied to crystals of corundum and topaz, with the result that both kinds of crystals were readily scratched by the carbonadoes. They were tested also by Chief Curator H. W. Nichols of the Department of Geology of the Field Museum of Natural History, Chicago, Illinois, who pronounced them carbonadoes.

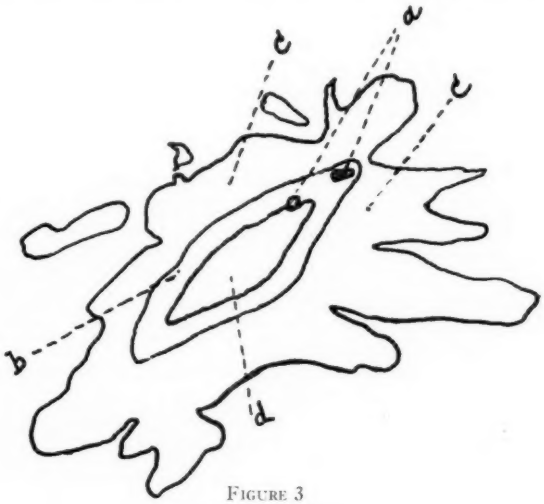


FIGURE 3

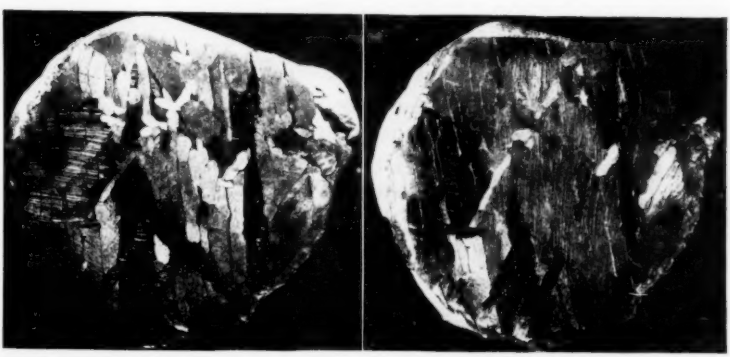
KEY MAP FOR FIGURE 2

a. Protruding carbonadoes
b. Zone of carbonaceous matter
c. Schreibersite
d. Cavity

Photographs of the Widmanstätten Structure of the Goose Lake, California, Siderite

By FREDERICK C. LEONARD

The two accompanying photographs were made of a small, near-end section of the Goose Lake, California, siderite (*v.* the writer, *C.S.R.M.*: *P.A.*, **47**, 322-4; **2**,



THE WIDMANSTÄTTEN STRUCTURE OF THE GOOSE LAKE, CALIFORNIA, SIDERITE, ×1½±

No. 2, 113-15, 1939), removed for study at the time (1939 May 3 and 4) of the transportation of the meteorite from its place of fall. The flat surface of the slice was polished, and etched with dilute nitric acid, and shows the Widmanstätten structure of the siderite, on the basis of which it has been classified as a medium-to-coarse octahedrite. The photographs were taken with side lighting. The direction of the illumination in the first view is at right angles to that in the second.

Notice of the Seventh Annual Meeting

The Seventh Annual Meeting of the Society has been scheduled by the Council to be held in connection with the regular winter meeting of the American Association for the Advancement of Science at the Ohio State University, Columbus, Ohio, on Thursday, December 28, and Friday, December 29, 1939. Joint sessions are being planned with both Section D (Astronomy) and Section E (Geology and Geography). The success of past joint sessions would indicate that no interested member should miss the coming meeting.

Members who are engaged in any kind of meteoritical research are cordially invited to present papers at this meeting. Titles and abstracts should be forwarded as soon as possible to the Secretary. Papers may be contributed by absent members as well as by members in attendance at the meeting.

1939 October 2

ROBERT W. WEBB, *Secretary*

Comet Notes

By G. VAN BIESBROECK

Several faint comets are under observation at this time, but only one comes in reach of moderate sized telescopes in the near future, namely, PERIODIC COMET 1939 *i* (TUTTLE) which has been followed since last August when it was rediscovered by H. M. Jeffers at the Lick Observatory. As was to be expected from the decreasing distance, the brightness has gained considerably. The comet will be nearest to the sun on November 11 and nearest to the earth a couple of days earlier. At that time it will be visible in the morning hours moving rapidly southward through the constellations of Sextans and Hydra. When most recently seen here (October 11) it appeared as a round coma some 3′ in diameter with a well-condensed central nucleus. The total magnitude was then estimated as 9.5 so that a maximum between 8th and 9th magnitudes can be expected in November.

EPHEMERIS OF PERIODIC COMET TUTTLE (CROMMELIN)

0^h U.T. 1939	(1950.0) α	δ
	h m	° ′
Oct. 24	9 56.8	+ 8 33
Nov. 1	10 17.9	— 2 4
9	10 39.9	—12 34
17	11 3.3	—23 56
25	11 29.2	—33 57

Both PERIODIC COMETS 1939 *e* (KOPFF) and 1939 *g* (BROOKS II) are slowly receding from the earth as well as from the sun and will be increasingly difficult to follow on account of their faintness, although they are well located for northern observers. COMET 1939 *h* (RIGOLLET) will soon also become a difficult object for small telescopes. On October 11 the rapidly-fading magnitude was estimated as 11 by the writer. The comet appeared as a very diffuse round coma.

Before the end of the year two periodic comets expected to be nearest to the sun in 1940 may be searched for: they are GIACOBINI-ZINNER (1933 III) due to reach perihelion in February, 1940, and FAYE expected at perihelion on April 23, 1940. The following ephemerides (1950), found in the *Handbook of the British Astronomical Association*, indicate the predicted positions which are none too favorable:

	GIACOBINI-ZINNER		FAYE	
	F. R. Cripps		W. P. Henderson & P. J. Harris	
1939	h m	° ′	h m	° ′
Nov. 1	16 55.8	— 0 48	20 11.8	—10 12
9	17 13.8	1 42	20 21.4	10 20
17	17 33.4	2 31	20 32.2	10 19
25	17 54.6	3 15	20 44.2	10 10
Dec. 3	18 17.4	3 52	20 57.3	9 52
11	18 41.8	4 21	21 11.4	9 25
19	19 8.1	4 43	21 26.3	8 49
27	19 36.1	— 4 55	21 42.0	— 8 4

Williams Bay, Wisconsin, October 12, 1939.

NOTE ADDED ON OCTOBER 16

In the evening of October 14 the faint trace of PERIODIC COMET GIACOBINI-ZINNER was found on a plate taken here with the 24-inch reflector. The magnitude was estimated as 15 and the comet appeared as a small and very diffuse coma. The ephemeris by F. R. Cripps is quite accurate. The correction is —7° in right ascension and —1′ in declination, indicating that perihelion will occur only $0^d.2$ later than predicted. The recovery position is:

1939 Oct. 15.05356 $16^h\ 21^m\ 27^s.42$ $+1°\ 18'\ 52''.0$

This comet was first discovered by Giacobini in Nice (France) December 10, 1900, and proved to have a period of 6½ years. In 1907 the conditions were unfavorable and the comet was not observed. But in 1913 it was independently found anew by Zinner. At the next return (1920) it was missed but was seen in 1926 and in 1933. This will therefore be the fourth observed return. Although the brightness is increasing somewhat this is not a favorable apparition. The comet will remain visible only at low altitude shortly after sunset. Perihelion occurs February 17, 1940, but the angular distance from the sun is small at that time.

VARIABLE STARS

Variable Star Notes from the American Association of Variable Star Observers

By LEON CAMPBELL, Recorder

The R Coronae Stars: R Coronae Borealis itself has been much in the limelight lately, both observationally and theoretically. The latest information indicates a second drop to a deep minimum since the variable began its sudden decline in light a year ago.

Recently J. A. O'Keefe, working with A.A.V.S.O. material covering many years, and studying the problem from the theoretical side, has shown quite conclusively by qualitative methods that these light variations can be well accounted for by the assumption that clouds of high carbon content are thrown off intermittently

from the atmosphere of the star. L. Berman had shown earlier that the atmosphere of the star contains vast quantities of carbon sufficient on O'Keefe's theory to obscure the light of the star in a sudden and irregular manner. E. Loreta, in 1934, suggested that nebulous material thrown off to some distance from the star could account for the observed variations.

Along this same line, L. Jacchia, in 1932, announced that RY Sagittarii, another R Coronae-type star, presented a fairly pronounced short term variation along with the more typical variations. He found evidence for the existence of a period of 38.6 days, this periodicity persisting even when the star was approaching a minimum, as well as at minimum. Later observations have confirmed this periodicity to a remarkable extent. Observations of R Coronae Borealis itself have shown that it also has a tendency to a small secondary variation, especially at maximum, although not so pronounced as that shown by RY Sagittarii. The similar stars SU Tauri and S Apodis, however, evince little tendency to change in light, except when they are well below maximum; especially is this true of S Apodis. It would appear that the cause of the R Coronae Borealis type of variation is very plausibly suggested by O'Keefe's theory.

A.A.V.S.O. Meeting: The twenty-eighth Annual Meeting of the American Association of Variable Star Observers at Harvard Observatory occupied the greater part of two days, October 13 and 14. Proceedings opened with a Council Meeting on Friday afternoon, at which 16 annual members and one life member were elected and thenceforward the Observatory grounds were literally covered with people and automobiles with home plates from Maine to Wisconsin, and points south. About 75 members and guests were present. The Friday evening program began with a joint meeting of the A.A.V.S.O. and the Bond Astronomical Club, at which Dr. Annie J. Cannon described her recent "Wanderings Along the West Coast" including the summer meeting of the American Astronomical Society at Berkeley, California; Lick, Mt. Wilson, and Hale Observatories, as well as Lowell Observatory and the Meteor Crater. Following this there was an illustrated lecture with colored movies of "Ancient and Modern Guatemala" by Mr. and Mrs. S. D. Weissman, not astronomical but, nevertheless, highly entertaining.

The regular business meeting of the A.A.V.S.O. started promptly at 10:00 A.M. on Saturday with President C. W. Elmer in the chair. Reports of officers and committees were first presented, including a résumé of the A.A.V.S.O. activities as brought out in the Recorder's report. Reference was made to the value of the A.A.V.S.O. Library, now numbering nearly 2000 books and pamphlets, and the Slide Collection, containing over 1000 slides. Both the book and slide collections are available to members on loan for reading and lecturing.

The report on the use of the A.A.V.S.O. telescopes by members was informative and, in general, quite satisfactory. The instruments on loan include refractors and reflectors, from 3 to 11 inches in aperture.

The annual summary referred to the work of the 135 observers, who have contributed 53,457 observations during the year just ended, thus completing a total of nearly three quarters of a million estimates during the 26 years since the observers first began to make and communicate observations as a unit to Harvard. Signor Eppe Loreta, of Bologna, Italy, headed the list with 5692 observations, while Joseph W. Meek of Tucson, Arizona, came second with 3523 estimations. George Herbig followed with 2831, E. H. Jones with 2748, F. Hartmann with 2653, and R. P. deKock with 2471.

The report of the Occultation Committee was of particular interest. One hun-

dred and thirty-four separate reductions of 67 occultations observed in the years 1937 and 1938 were made. Much time was spent by computers—especially the South Norwalk group—in preparing local tables in connection with the new Comrie method of reduction. Besides reductions, numerous observations of occultations were made by members from widely separated stations. Attention was called to the vast resources in the hands of telescope-makers who, were they so inclined, could very advantageously put their instruments to good use by observing occultations of stars. The main requirement, besides a telescope, is accessibility to accurate time—preferably through the medium of radio.

The report of the Photographic Committee, presented by Dr. A. E. Navez, outlined a well-conceived plan of attack on this somewhat recent phase of A.A.V.S.O. work. Mr. C. W. Elmer has already made a good start on photographing variable star regions for Harvard, J. L. Woods continues with his photographs of nebulae, and Milton Academy has launched a systematic program on variable star fields. New recruits with suitable equipment are eagerly sought.

The Nova Search Program has taken new life under the direction of the recently formed committee, and the appearance of a bright nova is the only thing needed to bring results.

Sun-spot work has come in for its share of interest; several observers are contributing results to the Sun-Spot Bureau at Zurich, Switzerland.

Auroral observations were discussed at length, and it was proposed to establish a committee to organize this branch of observation, new to the Association.

The following officers were chosen for the ensuing year:

Helen S. Hogg, Toronto, Canada, President
Dirk Brouwer, Yale Observatory, 1st Vice-President
Joseph W. Meek, Tucson, Arizona, 2nd Vice-President
David W. Rosebrugh, Poughkeepsie, New York, Secretary
Percy W. Witherell, Boston, Massachusetts, Treasurer
Leon Campbell, Harvard Observatory, Recorder.

Newly elected Council Members are:

Claude B. Carpenter, Wayne, Michigan
Casper R. Gregory, Scipio Center, New York
Winifred Kearons, Fall River, Massachusetts
Charles H. Smiley, Providence, Rhode Island.

The papers presented at both the morning and afternoon sessions covered a variety of subjects, from "Dew Chasers," by C. E. Fernald, to the more technical subject of "Eclipsing Variables" by the Milton Bureau staff. A paper on Cepheid variables was contributed by A. W. J. Cousins of Durban, South Africa. D. W. Rosebrugh described his "Week-end Observing Kit," T. R. Treadwell recounted the activities of the Amateur Astronomical Convention in New York in August, Miss Louise Ballhaussen and Edward A. Halbach discussed methods for observing and reporting aurorae, Mr. C. B. Ford gave a statistical discussion of the relation between periods and ranges in long period variables.

The Milton Bureau, which is devoting its energies to the study of the brighter variable stars on the Harvard collection of photographic plates, contributed a series of short papers on interesting eclipsing stars. One of the most remarkable of known eclipsing variables—V 367 Cygni—was described by Dr. Marie Pishmish, who has measured its brightness on 2000 plates. It resembles the well-known star β Lyrae, but its period is even longer. It consists of two large, massive, bright

stars, a little hotter than our sun, which are revolving, nearly in contact, in a period of about eighteen days, and are distorted by their mutual attraction into highly elliptical bodies.

Miss Virginia Brenton described the star UU Cassiopeiae, which consists also of two elliptical components revolving with their ends very near to one another; it is a far hotter star than V 367 Cygni, and the most remarkable thing about its variation is that its amplitude is so small—only three-tenths of a magnitude—and yet Miss Brenton has succeeded in measuring its brightness with such accuracy that an excellent light curve has been obtained.

Two eclipsing stars that depart noticeably from strict punctuality were described by Dr. C. P. Gaposchkin; AL Scorpii, which runs from too late to too early without apparent regularity, has been measured by Mrs. H. L. Thomas. The well-known Algol star, RZ Cassiopeiae, however, is shown by the measures of Dr. S. Gaposchkin and Mr. Luis E. Erro to depart systematically from strict punctuality, completing the cycle in about eighteen years. The same periodic change has been shown from measures of line-of-sight velocity, and there is little doubt that it is caused by a turning upon itself of the elliptical orbit in which the stars that make up RZ Cassiopeiae are travelling.

The galactic distribution of the known eclipsing variables was illustrated by Dr. S. Gaposchkin. It is an interesting fact that even from so special and limited a group of objects it may easily be seen that the galaxy is greatly flattened.

Dr. Luigi Jacchia's paper dealt with stars of the RR Tauri type in which he suggested a new classification with this designation including such stars as RW Aurigae, RY Orionis, SY Cancri, and CO Orionis, with criteria based on the peculiarities of their light curves. These stars are subject to sudden decrease in light, sometimes lasting not more than a few days, with no evidence of regularity in period or in range of magnitude.

After adjournment of the afternoon session, members joined the Harvard Observatory staff in celebrating the centenary of the establishment of a separate department of astronomy at Harvard by attending exercises at "Dana House" in Cambridge where remarks and addresses were made by Dr. Harlow Shapley, Miss Elizabeth Bond, and Dr. Daniel Norman. Miss Bond spoke of some incidents relative to the appointment of her grandfather, William Cranch Bond, as the first Astronomical Observer with headquarters at Dana House. Dr. Norman traced the early history of astronomy at Harvard with particular attention to seemingly futile earlier attempts to establish an observatory.

Following the dinner, Dr. Shapley gave his usual summary of the "High Lights of Astronomy" during the past year. Among the outstanding events were Dr. H. Bethe's contribution to the solution of the problem of the source of energy in the stars; the completion of the McDonald Observatory with its 82-inch reflector; the interpretation of the spectra of supernovae and the frequency of such novae in remote galaxies; and W. J. Luyten's discussion of the luminosity curve, based on his recent proper motion studies. Dr. Richard Prager and Dr. Luigi Jacchia, as guests of the Association, spoke on "Naming Variables" and "Tricks Played by Stars," respectively.

Messrs Boss and Carpenter finished off the program with movies of early and recent A.A.V.S.O. meetings.

The next meeting of the A.A.V.S.O. is scheduled for May, 1940, at the University of Toronto.

Observers and Observations during September, 1939

Observer	Var.	Est.	Observer	Var.	Est.
Albrecht	13	15	Kirkpatrick	37	114
Baldwin	96	146	de Kock	56	217
Ball, A. R.	24	30	Koons	42	50
Ball, J.	15	15	Lange	4	5
Ballhaussen	4	4		10	10
Benini	1	5	McLeod	19	30
Blunck	39	39	Murphy	14	14
Bouton	16	20	Needham	35	39
Brocchi	56	115	Palo	18	41
Buckstaff	29	150	Parker	16	19
Christman	21	48	Peltier	65	162
Cilley	32	48	Peterson	4	15
Dafter	6	19	Prinslow	6	6
Diedrich	24	35	Purdy	9	15
Economou	18	37	Pursell	3	5
Escalante	30	33	Rosebrugh	9	39
Evans	15	23	Russell	12	21
Fernald	114	182	Ryder	2	2
Ford	29	31	de Santis	3	3
Franklin	25	30	Schmid	22	25
Griffin	5	5	Schoenke	17	25
Halbach	7	7	Sill	107	109
Harris	17	17	Shafer	4	6
Hiett	10	13	Smith, F. W.	21	21
Hildom	19	35	Smith, J. R.	27	27
Holmes	3	3	Topham	18	18
Holt	95	174	Treadwell	24	55
Houston	130	470	Walton	12	27
Howarth	6	6	Webb	31	33
Jones	96	315	Whittier	8	8
Kanda	3	24	Yamada	8	44
Kearons	67	122	Yamasaki	24	24
Kelly	19	40			

October 19, 1939

Notes from Amateurs

Observations of Mars in 1937

The planet Mars always stands high in popular appeal; and it has been the author's intention, ever since hearing of those remarkable markings some have considered evidence of intelligent life, to observe this planet with a good telescope. It was with great pleasure, then that I observed Mars during the 1937 apparition at Mount Union College Observatory with a 10-inch refractor. Some observations were made at New Waterford, Ohio, with a 6-inch reflector. The program consisted of two major portions, drawings and color-observations. Work was carried on from March 22 to October 14; but almost all the valuable observations were made in May, June, and July. Magnifications employed ranged from 160× to 230×. The seeing was usually poor but occasionally became good. The season on Mars was late summer in the northern hemisphere and late winter in the southern hemisphere. The latitude of the center of the disk during May, June, and July was about 15° N. The northern hemisphere could consequently be observed better than the southern.

The maria of the planet are usually the most conspicuous feature. I am here briefly describing their aspect to me. For several reasons, however, among which are the facts of dependence chiefly upon my own observations, of the aspect being that at one Martian season only, and of some regions having been only poorly studied, this aspect may differ from that seen by other observers. Correspondence from others, either supporting or contradicting these aspects, will be welcomed.

Fastigium Aryn was usually its normal self. It was one of the darkest parts of the maria and it consisted of two forks. These forks were rather short. Margaritifer Sinus was seen as a long peninsula, extending well north of the equator, on six dates, three of which fell in early May. Such also seemed to be its appearance in 1935. But usually in 1937 Margaritifer was a mere stub of a peninsula. It was darker than the other maria near it and was sometimes very dark. The author saw Mare Acidalium as a distinct dark area on one date only, June 16, at other times he saw no darkening here but did see the sides of the region as *canali*. Latimer J. Wilson, also observing Mars, saw Acidalium well but found it vague when more than ten degrees from the central meridian. The author's failure to detect the region was perhaps due to temporary obscurations of the Martian atmosphere at those times when it was well placed for him. The author did, however, see a mark, the darkest one in its portion of Mars from May 7 to May 12 over a somewhat larger period, near N. lat. 45° and long. 60°. This mark was not possibly Acidalium but may well have been Labeatis Lacus. This mark was only an ordinary oasis in June and in July. Sinus Aurorae was a somewhat dark and stubby peninsula. The Solis Lacus region did not appear to resemble the maps much. The Solis itself was seen on four dates only. Nectar Canalus joined Solis on the east. Tithonius Lacus was one of the vaguer parts of the maria. Aonius Sinus was not the long narrow peninsula depicted on some maps. Mare Sirenum was rather dark and extended from 120° to 175°. Mare Cimmerium was somewhat light; its north shore may have been darker than the rest. Atlantis, the strait between Sirenum and Cimmerium and Hesperia, the strait between Cimmerium and Tyrrhenum, were seen a few times but were difficult. Mare Tyrrhenum was somewhat darker than Cimmerium, and Syrtis Minor was distinct. The Syrtis Major was by far the most prominent feature upon the planet. It was the darkest large area; and its north tip, named Euxinus by Professor W. H. Pickering, was the darkest mark on Mars. There was a narrow rift just above this tip. The south part of this area was less dark than the main portion, and a rift separated the two. After August 1, the Syrtis appeared to lack detail; but bad seeing may explain this lack. Several other observers saw the dark tip. The position of this tip may have been farther west than usual. The author deduced a longitude for it of 298° from drawings, with an error of several degrees. He made no micrometer measures. Wilson's longitude for this apparition is 290°. The usual position on maps is about 283°. Sinus Sabaeus was rather dark.

Lowell, Pickering, and others have observed seasonal changes in the maria of Mars, greens seen in the spring changing to grays and browns by autumn. Such seasonal color-changes constitute an excellent argument for vegetation. But little evidence of such color-changes was secured in 1937; the period of observation may have been too short. To the author the maria looked gray or gray tinged by brown. A possibly increasing brownishness in July is unlikely, for spring was coming in the southern hemisphere. Hugh M. Johnson of Des Moines saw the maria as gray or bluish gray. Ed Martz of Chicago occasionally perceived greens. To the author, Sabaeus looked brownish irregularly; but observations were insufficient to

determine just how the hue varied. The very dark northern area near 60° (probably Labeatis) already mentioned was deep blue while it was very dark but lost this hue when it faded. The author half-suspected bluish tints in Margaritifer, Tithonius, Bosporus, Gemmatus, and Ceraunius at various times. But by far the most certainly colored region was Euxinus, the tip of Syrtis Major. Here I saw, in mid-May and again in late June, a deep blue color. The tint could not be seen at the end of July. Professor Pickering studied this blue in Euxinus in previous years, and Ed Martz saw it at this apparition. Johnson saw bluish shades in high northern latitudes near 300° on June 26.

Mars at this apparition appeared to lack polar caps as dinstinct as those usually seen. The author did not see in April to August, 1937, polar caps as bright, as white, and as conspicuous as he did in May to July, 1935, at the same Martian season. In 1937, he saw a distinct north cap on only three dates in early May. He did, however, observe regularly the color of the north polar region. This hue was sometimes yellow and sometimes white. The white was a dull white, often a mere white tinge to the yellow. Such white hues were seen from May 25 to June 3, and on June 13, June 20, June 25, and June 30, from July 7 to July 19, on July 27 and July 29, on August 15, and from September 22 to October 6.

If we consider white the color of a true snow-cap, similar to that of other apparitions, and yellow the color of some medium (dust, haze, cloud, etc.) obscuring the true cap, we have evidence that this medium thinned at the end of the northern summer and was gone completely by mid-autumn. From April 12 to May 7 a vague, small, whitish yellow south cap was seen. During the rest of May, except on May 30, the southern hemisphere south of the maria was sensibly yellow in color. On May 30 Latimer J. Wilson saw flashes near the south rim which he attributed to reflections of sunlight from the sides of the plateau Thyle II (refer to POPULAR ASTRONOMY for October, 1937). To the author the south polar region was sometimes, but not always, whitish in June and July. From September 15 to October 14, it now being mid-spring in the southern hemisphere, the author saw a large, conspicuous, bright, vivid white south cap. This cap certainly resembled the snow-cap of previous apparitions and was a brighter tone of white than earlier in the apparition. Among other observers, several confirm the author as to the absence of distinct snow-caps in the April-August period. Ed Martz last saw the north cap in mid-April and did not afterwards see distinctly either cap. Phillips in England found only a whitish area in the polar regions. Wilson and Johnson saw dull white polar areas, such areas hardly suggesting the usual snow caps. On the other hand, Dr. E. C. Slipher of Lowell Observatory thinks that there is photographic evidence for the existence of both polar snow caps.

No discussion of Mars could be complete without mentioning the *canali* and *oases*, the subject of so much controversy in the last few decades. That there does exist a network of bands and associated spots upon Mars can no longer be doubted by those who fair-mindedly weigh the evidence. Scarcely anyone who has ever made a real study of Mars has failed to see these bands. Dozens of *canali* have been photographed at Lowell Observatory apparition after apparition. Ed Martz saw and photographed a number of them in 1937. The author could draw dozens of them, not only with the Mount Union refractor but also with a 6-inch reflector. Wilson has drawn them for years, and Johnson saw a few of them. Finally, when certain *canali* are drawn in the same position, year after year, by different observers, there ought to remain little doubt of their actual existence. To be sure, different observers see the *canali* very differently. Lowell drew them as hair-lines;

Antoniadi draws them as blotches; most observers are intermediate between these two. To the author, the *canali* are rather narrow, are usually somewhat curved, and almost invariably have small, dark, round spots (*oases*) at their junctures. Some observers assert, and others deny, that the *canali* at times become doubled and consist then of two parallel components. The author suspected this phenomenon in six different *canali* on six different dates but suspected that perhaps such *canali* were only unusually wide and had dark edges. Both Cerberus and Aethiops seemed double on both April 23 and April 24. All other suspected doublings were seen only once. The following is a list of those *canali* and *oases* best seen by the author in 1937. The generic names (Lacus, Palus, Fons, etc.) of *oases* are omitted.

Canali		Oases
Acheron	Laestrygon	Asoraeus
Aethiops	Nasamon	Charontis
Asopas	Nepenthes	Coloe
Boreosyrtis	Nilokeras	Hecates
Cerberus	Nilosyrtis	Hephaestus
Cyclops	Orontes	Ismenius
Deuteronilus	Oxus	Lunae
Euphrates	Plutus	Moeris
Fortoena	Protonilus	Niliaous
Ganges	Sirenius	Nuba
Hydraotes	Thoth	Oxia
Hydraspes	Titan	Siloe
Indus	Triton	Sirbonis
Issedon		Triton

Although at times the atmosphere of Mars was unprecedentedly clear in 1937, so that photographs made in blue light actually revealed surface detail, there was much evidence of atmospherical obscurations on many dates during the apparition. Wilson, Johnson, Martz, and the author found that at times, under splendid conditions, Mars showed little contrast. On March 22, in splendid seeing and a clear sky, the author found Mars almost entirely lacking contrast. On June 4, he found contrasts so vague that he attempted no drawing though he had made several under identical terrestrial atmospherical conditions. Several observers saw bright white areas upon the limbs, especially upon the sunset limb. The author saw the sunset limb thus whitened more in June and in September than in July; Johnson saw almost no such white areas before July 20. Johnson and the author never saw such white areas centrally placed; Martz photographed them in that position; and Roth, Mount Union student, whose eye is unusually sensitive to white areas, saw white regions in the center of the disk on June 3. The evidence of Martz's photographs, however, would indicate that at least some of these bright areas are frost rather than cloud. But some other temporary abnormal aspects of certain regions are best attributed to atmospherical obscurations; *i.e.*, clouds of one sort or another. The author saw a horizontal rift in the southern maria over Pyrrhae Regio on June 20 and a rift in Margaritifer on May 12. Johnson saw a break in the maria near Margaritifer on June 15. Martz, Wilson, and the author all found detail west of Solis Lacus vague and unlike maps, as though it were obscured. It is the author's plan to continue observations of Mars in 1939, and he will welcome correspondence with interested observers.

Walter H. Haas.

Mount Union College, January 9, 1938.

Mars, Jupiter, and Saturn

Mars in late October is still a conspicuous red star in our night sky but except at times of good seeing is not a satisfactory telescopic object. The south polar cap seems to be at a standstill or else is covered with cloud. The dark border is not discernible here and the cap seems larger than a few weeks ago. Owing to unsteady air the markings are not easy to make out. Mars now is about 60,000,000 miles away so the disc is not large. In my previous note I mentioned seeing easily the hump on the Margaritifer Sinus. What I should have said was the point of the Margaritifer Sinus. The Syrtis Major has the hump and the whole marking was distinct and sharp when centrally located. At times of good seeing the sharpness of outline of all markings was greater than appears in most drawings, but the contrast was not so great as the engravings usually indicate.

Jupiter being in opposition is a fine object now and owing to the inclination of its equator to the ecliptic and position of nodes the satellites get into the most freakish visual positions. The planet seems as sharp as a steel engraving with belts visible almost from pole to pole. The waviness of the belts is noticeable.

Saturn is getting into better position steadily and already the rings are showing the main division and belts show dimly on the body of the planet. Two satellites show at present with powers of 225 and 300.

W. E. Duckwall.

Hillsboro, Ohio, October 20, 1939.

Communications and Comments

Under this heading we shall publish from time to time such material as does not properly fall under any of the established headings of this journal. Here, too, may be found, when occasion arises, articles which the editor may not be willing to give sanction to but which, nevertheless, may be provocative of thought along new lines.

Life on the Moon

The earth's air pressure at sea level averages 30 inches, which seems to be a favorable pressure for a varied and abundant life. On mountain slopes, 20,000 feet above sea level where the barometer shows ten inches of pressure, life has been found to exist in considerable variety and number. In case of Mars, Lowell, assuming a total albedo for the planet of .27 and .10 for its surface, deduced a depth of air equal to 17/75 of ours,which under the lower surface gravity there of .38 of ours gives a final result of 2½ inches of barometric pressure for the Martian surface. However, assuming that Mars is supplied with air in proportion to its mass and allowing for surface area and surface gravity, the barometric pressure comes to 4.2 inches. Therefore the air pressure on Mars would seem to be somewhere between these limits and applying the same reasoning to the moon we would have a range of barometric pressure there from 0 to 5/6 of an inch, according to how we rate its albedo or whether we use its mass, surface area, and surface gravity to arrive at an estimate of its barometric pressure. We, of course, do not know that the earth, Mars, and the moon were endowed with air in proportion to their respective masses or what the rates of loss into space or into chemical compounds were for the three bodies.

The moon is generally considered airless and barren of life and its appearance

justifies this conclusion. No doubt many other observers have studied the moon's surface night after night when the seeing was good, looking for some sure indication of change and perhaps hoping a sizable meteorite would strike in one of the smooth areas, so we could see what would happen; whether a crater would result, whether a cloud of dust would rise and float off, and in what direction.

We have studied the moon's surface directly and in photographs and all the changes we are sure of seem to be due to sunlight shining at varying angles on broken reflective surfaces which may easily change in appearance as they become heated by the direct rays of the sun. We all have seen rays and certain craters flash out brilliantly near full moon far beyond the brightness afforded by slant illumination. This must be due to changes induced by heat or more probably to more direct reflection from unweathered surfaces of broken-up glass-like substances such as quartz or granite.

We are familiar with the work of Pickering but since we so easily see the seasonal changes that take place on the more distant Mars we should hope to see some of the changes he saw on the moon even after allowing for the excellent telescopes he used and the fine air conditions over the interior highlands of Jamaica.

That changes in appearance perceived on the moon in certain areas may be due to heat, seems to be indicated by the results of observing the moon just before and after a total lunar eclipse. Promising results have been secured, which seem to indicate that great heat on the moon's surface, followed by sudden cooling and rapid reheating, induce visible effects. However, the existence of organic life on our satellite must depend on the presence of moisture there. Granting a supply of air there too small for detection the moisture must have vanished into space or into the body of the moon long since. It seems highly improbable that any form of life could stand 14 days of scorching heat followed by 14 days of the cold of space, whether moisture and air be present or not. Changes in the appearance of the moon's surface then, must be due to other causes than any form of life.

W. E. DUCKWALL.

Hillsboro, Ohio

General Notes

Dr. Andrew Claude de la Cherois Crommelin died in London on September 20, at the age of 74 years.

Dr. Erik Holmberg, of the Lund Observatory, Sweden, is now in residence at the Leander McCormick Observatory.

Dr. Frederick C. Leonard, of the Department of Astronomy, University of California, Los Angeles, delivered an illustrated lecture on meteorites before the Victoria Center of the Royal Astronomical Society of Canada, at Victoria College, Victoria, B. C., on the evening of August 28, 1939.

Dr. Loring B. Andrews is giving a series of astronomical talks, one each week at 10:30 P.M., E.S.T. The title of the series is "Looking Starward" and may be heard as a broadcast of the World Radio University, Boston. The stations partici-

pating in the broadcast are WRUL operating on 11.73 magacycles (25.6 meters) and WRUW operating on 15.13 megacycles (19.8 meters). This series is planned to foster a close association between the broadcaster and his listeners. To accomplish this questions are invited from those listening to the lectures.

European Journals and the War

The non-receipt by a subscriber of any European chemical or other scientific journal seriously needed as research material should be promptly reported to the American Documentation Institute.

The Cultural Relations Committee of ADI, which coöperates closely with the Cultural Relations Division of the Department of State, is working on this problem, and hopes to be able to surmount such war obstacles as interrupted transportation, embargoes, and censorship, which so grievously affected the progress of research during the last war.

The principle should be established, if possible, that the materials of research having no relation to war shall continue to pass freely, regardless of the countries of origin or destination.

Reports, with full details of where subscription was placed and name and address of subscriber, volume, date and number of last issue received, should be addressed to:

American Documentation Institute,
Bibliofilm Service,
Care of U. S. Department of Agriculture Library,
Washington, D. C.

Northern Lights at Berea, Kentucky

The Northern Lights were observed for several minutes before 9:30 P.M. on October 3, 1939, at Berea, Kentucky. Even though the moon was rising, yet streamers of light raced upward toward the zenith. Some emanated from west of north; others east of north. One happened to extend upward approximately to the zenith, passing one degree west of Polaris.

At 9:30 a strong cloudy light was noticed on the northern horizon. As a fan-shaped white cloud of light it seemed to originate near the end of the handle of the "Big Dipper." The upper part of the fan pointed toward Capella, extending two-thirds of the distance to it. Elsewhere on the horizon there was an absence of light. Even a gigantic searchlight on a college tower in the west failed to compete with this fan-shaped light, which the moon seemed to augment near the horizon.

W. R. HUTCHERSON.

Eclipse Cycle

On October 12, 1939, a solar eclipse took place which was total and central only in very high southern latitudes. This eclipse is the last total and central one of the series. Herewith are given the dates of the very first and very last partial eclipses of the series, the first and last central ones, the middle one, the date when the series changed from annular to total, and the date of the total eclipse of the series having the longest duration of totality on the central line. One peculiarity to be particularly noted is the short period from the first partial to the first central

eclipse of the series (108 years), and the long period from the last central to the last partial one of the series (379 years).

1. The first eclipse of this series was a very small partial one visible in high northern latitudes on April 29, 1074. The moon's mean anomaly was, 184° 36′; the sun's 135° 20′.
2. First central and annular eclipse of this series took place on July 2, 1182. Moon's mean anomaly, 167° 23′; sun's, 198° 18′.
3. Middle eclipse (also annular) of the series took place on March 29, 1615. Moon's mean anomaly, 98° 56′; sun's, 90° 10′.
4. The change from annular to total eclipses occurred on May 23, 1705. At the time of this eclipse the moon's mean anomaly was 84° 45′; the sun's was 142° 38′. The moon's shadow just reached the earth.
5. The eclipse with the longest duration of totality of this series on the central line took place on September 8, 1885, and was visible in the South Pacific ocean. Moon's mean anomaly, 56° 31′; sun's, 247° 35′.
6. Last central eclipse of the series took place October 12, 1939, central only in Antarctic regions, very close to the south pole. Moon's mean anomaly was 48° 5′; sun's, 279° 4′.
7. Last partial eclipse of this series will occur on May 30, 2318. Moon's mean anomaly, 349° 14′; sun's, 139° 26′.

Lewis J. Boss.

Seagrave Memorial Observatory,
North Scituate, Rhode Island, October 17, 1939.

Book Reviews

A Hundred Years of Astronomy, by Reginald L. Waterfield. (Duckworth, 3 Henrietta St., London, W. C. 2. 526 pages. 21/— net.)

Astronomy has been described as the oldest of the sciences. It is true that as soon as man had lifted his shoulders from the earth he also lifted his eyes to the stars. Yet it took the discovery of the telescope to put astronomy in the realm of the exact sciences. Modern astronomy as we know it today is scarcely more than a hundred years old, dating from the time of the Herschels.

The author of "A Hundred Years of Astronomy" has attempted to describe the drama of these last hundred years. A glance at the contents will give an indication of the wide diversity of subjects treated. Among the thirty chapters there may be found titles like these: "Early Advances, and the First Measurement of a Star's Distance," "The Measurement of Stellar Brightness and Eclipsing Variable Stars," "Sounding the Depths of the Universe," "The Galactic Nebulae," "The Absorption of Light in Space," "Recent Work in Solar Physics," and many others equally as promising. Each chapter is somewhat of a unit unto itself, the progress from the earliest times being described for each subject as it comes up.

An immense amount of research must have gone into the preparation of the book, as can be attested to by the representative list of titles and authors to be found in the index. It is not a history and not a textbook. It is written so that the layman with a minimum amount of knowledge of the subject can understand the most abstract theory. A keen appreciation for the human side of the subject has caused the author to fill every page with references to this or that worker. One glimpses the vision of hundreds of devoted men down through the century all working toward a common end, all adding their contributions to the building of

the whole. The reader is left with the impression that here is a subject that is growing; much has been done that is of inestimable value, but much more remains to be done. More questions are asked than are answered. It is an inspiring picture that is painted.

All in all, one may say that here is a book that astronomers, teachers, students, and laymen have long been waiting for. A summary of things achieved, it is a challenge to men everywhere to make the next hundred years of astronomy as glorious and as fruitful as the last.

JOHN G. PHILLIPS.

Carleton College, Northfield, Minnesota.

Solving the Mysterious Universe, by Ernest Augustus Thomas, M.R.S.T. (Allenson & Co., Ltd., London, E. C. 4.)

The reviewer is disinclined to commend this book, due to the author's having incorporated therein theories, promulgated by himself, which appear to be scientifically questionable. In addition, the text does not seem to have been carefully checked for accuracy of statements. On page 119, for example, the author states, "To an observer, the light from a star revolving in its orbit obviously travels faster when the star is approaching towards, than when receding from him. It is this difference in the rate of speed of the light from the star that causes the shift of the lines in the spectrum." If the reviewer were to find this explanation of the Doppler effect in one of his student's blue books, he would be tempted to assign the grade *zero*.

The book also contains factual misinformation, such as the remark on page 90 to the effect that Jupiter has eight satellites and Saturn ten. The literary style of the book is in places quite muddled, as for example: "Instruments for the purpose of probing into the infinite abyss (*i.e.*, the universe) have been so constructed as to push farther and farther back the visible boundaries of space, so that, now the great 100-inch telescope at Mount Wilson has enabled man to peer very profoundly indeed into the deepest depths of the deep profound." R.S.Z.

THE OBSERVATORY

High above the city's din and rush,
Result of mankind's cultural advance,
Robed in starlight's sacred, soothing hush,
A force for good, a source of joy it stands.
Within that dome, like magic, mystic eye,
The telescope, not only to a few,—
A learned, earnest few,—reveals the sky,
But also draws the masses the stars to view,
To briefly slip away from toil and care,—
From all that holds the mind on things of earth,—
The radiant splendor of the spheres to share,
To sense the firmament's eternal mirth,
In silence on celestial beauty gaze,
Absorb the peace which permeates all space.

—LISA ODLAND.

POPULAR ASTRONOMY

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